DAIRY CATTLE AND MILK PRODUCTION

CLARENCE H ECKLES, *noted scientist teacher, and authority in dairy husbandry*

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BY

CLARENCE H. ECKLES, B S A , D SC

Late Chief, Division of Dairy Husbandry University of Minnesota
Formerly Professor of Dairy Husbandry, University of Missouri

REVISED BY

ERNEST L. ANTHONY, B S , M S , D SC , D AGR

Dean Emeritus of Agriculture, Michigan State University

CONTRIBUTING AUTHORS

DR H O HENDERSON
Head, Department of Dairy Husbandry, West Virginia University
Morgantown, West Virginia

DR N P RALSTON
Head, Dairy Department, Michigan State University
East Lansing, Michigan

DR R B BECKER
Professor of Dairy Husbandry University of Florida
Gainesville, Florida

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PREFACE

Dairy Cattle and Milk Production, first published in 1911 by Dr. C. H. Eckles, for nearly a half century has met with widespread favor from teachers of dairy husbandry and from dairy farmers. Since the first edition appeared, the available knowledge of dairy husbandry has been greatly broadened by scientific investigation, especially in the field of nutrition, physiology, genetics, and veterinary medicine. This new edition, while retaining the plan and style of the former editions, has been completely reorganized, revised, and rewritten where new material and new topics seemed desirable. It has been the aim, however, not to destroy the style or character or authority of the work of its original author.

The introductory chapter presents the basic economic reasons for the growth of the dairy industry and important facts of a historical nature. The arrangement of the material concerning the breeds, which has always met with such genuine approval in the other editions has been retained.

Special attention has been given to the problems of animal breeding. The chapter entitled "Dairy Cattle Breeding" deals with the fundamentals and points out the extent to which applications of Mendel's Law may be made. The practical application of breeding, together with the selection of the sire, has been given detailed consideration. The business side of the registered-cattle business, which is of special interest to breeders of registered cattle, is covered in some detail in a separate chapter. A new chapter on "Artificial Insemination" has been added.

The material on calf raising has been expanded and revised in keeping with the newer knowledge and progress in this field. The old

chapter entitled "Factors Influencing the Growth of Cattle" has been completely rewritten and is intended to present the latest scientific viewpoint as to growth

The subject of feeding is covered by four chapters As in the previous editions, the subject is approached through feeding practice rather than through the presentation of a study of feeding standards Two chapters deal with the practical questions of feeding practice and a new chapter has been added on "Digestion in the Ruminant" A separate chapter deals with common feedstuffs, while feeding standards are considered in some detail Special attention is also given to silos, silage, and pasture

Milking and factors influencing the composition of milk receive the detailed treatment which the importance of these subjects justifies

It was the aim of Dr Eckles to bring together in this book the essential information regarding the dairy cow An immense amount of material now exists on the subject It is found in publications of experiment stations and scientific journals, in the agricultural press, and in the possession of practical herdsmen Dr Eckles drew upon his own vast experience gained through major research during a period of twenty-five years and with a dairy herd of from thirty to one hunred head of purebred animals, including the leading breeds He also drew upon his firsthand information and observations gained in extensive foreign study It was his aim to assemble and present this information in a suitable form for the student of dairy husbandry He had world-wide recognition as an authority in his field As a teacher who knew students and their needs he had no equal Although written primarily for the student of agriculture, this original text has proved to be equally popular with practical dairymen throughout the world It is hoped it will continue to be serviceable to the practical dairyman as well as to the student

This present revision by a former student of Dr Eckles was undertaken by invitation of Mrs Eckles In this revision I have been assisted by two former students of Dr Eckles, nationally recognized as authorities in their fields Dr H O Henderson of West Virginia University has rewritten the chapters on "Growth", Dr R B Becker of the University of Florida has rewritten the chapters on "Nutrition"

as well as the new chapter on the "Digestion in the Ruminant." Dr. N. P. Ralston, Michigan State University, has rewritten the chapter on "Dairy Cattle Breeding." Their contributions add greatly to this revision. It has been a work of love and humble appreciation and is offered as a part of the great debt we owe a great dairy leader, scientist, and teacher, Dr. Clarence Henry Eckles.

ERNEST L. ANTHONY

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CHAPTER I

Introduction

IMPORTANCE OF DAIRY FARMING

Milk Use. Milk, with its products, serves as one of the most important sources of food for all civilized nations. The more highly developed and prosperous the people, the greater the amount of milk and dairy products they consume.

Martiny[1] points out that the native races of Africa, America, and Australia, which have never developed beyond the stage of barbarism, do not use milk as food. The primitive races of Europe and western Asia made use of milk, as their descendants have done, and this fact, according to Martiny, in no small degree may be the reason for the great intellectual development of Europe and America.

McCollum, in presenting the results of his investigations in human nutrition, which have changed the viewpoint of the entire civilized world on the subject, remarked: "The keeping of dairy animals was the greatest factor in the history of the development of man from a state of barbarism."

A large part of the best and highest-priced agricultural lands of the world are utilized for the keeping of dairy cattle. It is a well-known fact that the most prosperous nations, as well as the best developed physically and mentally, are those in which the dairy cow has long been the foundation of agriculture.

History. As far back as history records, man has been in possession of cattle and has made use of milk and of products made from milk. In the oldest part of the Bible, references are made to milk,

[1] Martiny, Benno, Kirne, and Girbe. Berlin, (1895).

butter, and cheese[1] The people of Greece, 1000 to 450 B C, used butter and cheese, and one of their writers described the composition of milk The people of Rome, 750 B C to A D 475, used dairy products, and cheese became an important article of commerce From Rome a knowledge of the use of milk and its products spread over Europe By A D 800 the use of cheese was common in what is now Germany The Normans, who were powerful at this period, also used cheese as a common article of food

During the Dark Ages the art of cheese making was best known and largely developed in the monasteries The monks for several centuries were the leaders in carrying on the business and in teaching it to others By the year A D 1000, cheese had become an important article of trade in the cities of Europe, and by the fifteenth century some important cheese markets were in existence in Switzerland which were conducted very much as they are at present One type of Swiss cheese introduced by the monks has been made in the same region and under the same conditions since about the tenth century

Holland and Switzerland were the two early centers of development of the dairy industry in Europe, and they have retained this position to a large extent up to the present time The English apparently learned the use of milk—especially in the form of butter and cheese—from the Romans

We are indebted to Europe for our breeds of dairy cattle, for most of our basic knowledge of dairying, and for our earlier practices in regard to using milk and our methods of manufacturing products from it Although the first cattle were brought to America by Columbus on his second voyage the development of dairying in the United States was slow for more than a hundred years after the first settlement The early settlers in practically all cases brought animals with them from their native homes These were mixed indiscriminately, and from these sources are descended the cattle known as "natives," which until the widespread introduction of improved blood in recent years included a large proportion of the early cattle of America

For about two hundred years after the first settlements were made, practically no improved blood, in the present meaning of that term,

[1] Genesis 18 8 Judges 5 25 Psalms 55 21

was introduced from Europe or was available here. Beginning about 1820, importations were made, from time to time, of an individual or a small group of animals representing the various improved breeds since then well established in America. It was not until nearly fifty years afterward that herd books were established for the registration of pedigreed animals of the present dairy breeds.

In the colonial days in America the cow was seldom expected to produce milk in winter time. She calved in the spring, milked fairly well on grass, dried up in the fall, and sometimes died of starvation during the winter. Children's health suffered for lack of milk. Utensils and methods were crude and the products inferior. Dairying was distinctly a home or domestic activity.

These conditions changed slowly up to 1850. Since that date more progress has been made in the dairy industry than has been made from the dawn of history up to that time. This progress was made possible by the use of science in dairy practices. This date marks the change from the art of dairying to the science of dairying. The great landmarks in the development of the dairy industry in America since 1850 may be enumerated as follows:

Shipping milk. The first milk train was run in 1850. At this time the milk supply of the cities either came from cows kept within the city or was hauled from short distances.

The factory system. The introduction of the factory system of dairy manufacture has had widespread influence upon the entire industry. The first cheese factory was established by Williams in Oneida County, New York, in 1851; the first creamery by Stewart in Iowa, in 1871.

Condensed milk. Condensed milk was invented by Gail Borden, an American, in 1856. By 1920, 5.3 per cent of the milk production in the United States (the product of one and a third million cows) was used for this product. At present about 7.6 per cent of the total is condensed, evaporated, and dried.

Dairy organizations. In 1850 there were no dairy organizations. The dairy breed associations were established between 1860 and 1880 and the state dairy associations mainly between 1875 and 1895. The first cow-test association in America was organized in 1905.

The movement for co-operative manufacture and marketing of dairy products began between 1890 and 1900

The centrifugal separator The centrifugal separator was invented about 1877 The power size was put into use in 1879, and hand machines were introduced about 1890 The separator has revolutionized the dairy industry

The Babcock test The Babcock test was invented in 1890 Today cream and milk worth billions of dollars annually are universally sold according to this test

Cold storage Artificial refrigeration, introduced about 1880, has had a far-reaching effect upon markets and prices by making dairy products available everywhere, thereby tending to stabilize prices and supply

Relation of bacteriology to dairy products As a result of discoveries in the field of bacteriology, the close relation between bacteriological action and the quality of the manufactured dairy products is now recognized, also the importance of safeguarding dairy products designed for human food

Educational agencies Agencies have been established which include the organization of dairy instruction in agricultural colleges, in school, and in extension activities

Milk in relation to human nutrition Beginning about 1910, investigations in nutrition have shown, through the new knowledge of vitamins, proteins, and minerals the true importance of milk in the diet.

Improvement in cattle Between 1860 and 1880 widespread interest developed in importing carefully selected cattle of the various breeds from the best herds of Europe This was the foundation stock from which most of our present dairy stock have descended An average production of 225 pounds of butter per year for a herd was held as unusual in 1860 At present an average of 400 pounds for a herd, depending on the breed and locality, is considered the desirable goal for efficient production, and most good herds exceed this

Number of Dairy Cows in U.S Table 1 shows that the ratio between the human population and the number of cows in the United States has remained essentially the same since 1850 This does not

indicate that the consumption of milk per capita has remained constant. It has in fact increased considerably in recent years; but at the same time the average milk production per cow has also increased, making it possible to supply an increased demand with a somewhat smaller number of cows per thousand of people. Because the largest

Table 1. Population and Number of Dairy Cows on Farms in United States Exclusive of Outlying Possessions

YEAR	POPULATION	NUMBER OF DAIRY COWS	NUMBER OF PERSONS PER COW
1850	23,191,876	6,385,094	3.6
1860	31,443,321	8,585,735	3.7
1870	38,558,371	8,935,332	4.3
1880	50,155,783	12,443,120	4.0
1890	62,947,714	16,511,950	3.8
1900	75,994,575	17,135,633	4.4
1910	91,972,266	20,625,432	4.5
1920	105,710,620	23,724,148	4.0
1930	122,775,046	23,032,000	5.3
1940	131,669,275	24,074,000	5.4
1950	151,132,000	24,573,000	6.1

amounts of meat are required for persons doing heavy labor, meat is of decreasing importance in the present day when machines have taken over much of the heavy labor formerly done by human beings. The tendency is to use less of it and more of dairy products. This practice will undoubtedly continue in the future. Good roads and improved means of transportation have made it possible to give everyone a more complete supply of dairy products daily. This has been an important factor in increased yearly consumption. It may be expected that dairy products will be consumed in larger quantities, and together with fresh fruits and vegetables will cause great changes in food habits in the United States.

Table 2 shows the total number of cattle and the classification of dairy cattle as enumerated by *Agricultural Statistics*, 1953.

The difference between the figures given for dairy cows in this table and the figures in Table 1 results from the change in age classification. The figure given in Table 1 is estimated by the Census

Bureau for comparison The total value of dairy products in 1909 was, in round numbers, 596 million dollars, in 1919 it reached a total of one and half billion—an increase in value of 148 per cent in ten years It is now spoken of as the six-billion-dollar industry and is the leading source of income to American farmers

Table 2 Cattle on Farms (1953)

Total cattle	93 696 000
Beef cattle total	56 817 000
Dairy cattle total	36 879 000
Heifer calves under one year	6 913 000
Heifers 1 year old and under 2	5 9 0 000
Cows 2 years old and over	23 996 000

Milk as a Food From the earliest historical times, all civilized nations have used milk and its products as food It has long been observed that most human beings have a natural craving for milk, which is especially noticeable when they have been completely deprived of milk and dairy products for several months Its importance as a food for infants is also generally recognized However, the full explanation of the important relations of milk to the diet has been forthcoming only within the past half-century

Previous to the investigations of McCollum Mendel, and others, milk was valued as food from the same standpoint as other food products—that is, as a source of bodily energy and of protein On this basis milk makes a very favorable showing Now, however, as a result of the investigations referred to it is recognized that the question of a proper diet is far more than one of supplying a sufficient amount of energy and of protein The proteins must not only be ample in amount but of suitable kinds and quality Proteins from grains and vegetables are somewhat lacking in quality and their deficiencies are best made up by the use of some animal protein Of all animal proteins, those of milk are the best adapted for making up what is lacking in a ration largely composed of cereals This is true for animals as well as for man—as is illustrated by the remarkable results of adding skim milk to a grain ration received by pigs or fowls

The second remarkable discovery that greatly emphasizes the value of milk as food was that of the vitamins. These substances, of which many have been discovered so far, are necessary either for the growth or other functions of the young and for the well-being of mature humans and animals. They are produced primarily by plants, from which source man and animals must get them directly or indirectly. Four or five of the more important vitamins are found abundantly in milk, and many of the others to a lesser degree. One of these, vitamin D, is being added by various procedures to an increasing bulk of market milk. No other single food contains so many of the known vitamins, so that man has come to depend largely upon milk and dairy products for several of these indispensable substances.

A third great advance in the knowledge of nutrition concerns the mineral requirements. It has long been known that certain minerals are necessary for both man and animals. Only in recent years, however, has the extent to which man and domestic animals suffer from a deficiency of certain minerals been recognized. Lime is the substance most often lacking, although phosphorus—and at times iodine—are also consumed in too limited quantities. Milk is an especially good source of lime and phosphorus.

McCollum says, "Milk is the great factor of safety in making good the deficiencies of the grains which form, and must continue to form, the principal source of energy in our diet. Without the continued use of milk, not only for feeding of our children but in liberal amounts in cookery, we cannot as a nation maintain the position as a world power to which we have arisen."

The experience of mankind for thousands of years has shown the absolute need of milk in the diet. One of the best-known authorities on human nutrition said, "Without milk the white race cannot survive." We may remark that all mankind, not only the white race, requires milk for essential growth and survival. Milk and its products are essential human foods. Furthermore, the reasons why milk is an absolute necessity in the human diet are now understood and, as a result, the consumption of dairy products in the future is certain to increase. It is also shown that the cow returns more human food from a given amount of feed than any other domestic animal.

THE PLACE OF DAIRY FARMING IN A PERMANENT SYSTEM OF AGRICULTURE

Dairying a Permanent Industry. A study of agricultural development in the past removes any question as to the permanent character of dairy farming The history of agriculture in all civilized nations shows that grain-growing is usually the first type of farming developed The next stage in the history of agriculture is a decline in the fertility of the soil and in grain production—the result of continued cropping This results in greater attention to livestock of all kinds As a rule, the first cattle industry of any magnitude is that of beef raising, which is followed by a gradual change to dairy production, combined with more or less general farming When this stage is reached, the fertility of the soil is retained or improved, and a permanent form of agriculture is started The dairy districts of Europe have gone through these stages, they were at one time chiefly grain producing regions, later engaged in beef production, and in turn have become the dairy centers of the world

A considerable portion of the United States has already passed through these successive stages With other portions, the changes are still in progress As examples of states where these stages of development are reasonably complete the following might be mentioned New York, Pennsylvania, Ohio, Wisconsin Minnesota, and Michigan The history of agriculture shows that dairying is a permanent type of agriculture, and in later paragraphs the reasons are explained

The most practicable means of keeping up the fertility of the soil is the use of farm manure made possible by the keeping of a liberal number of live stock These facts furnish a firm foundation for the faith of the dairy farmer in the permanent character of his industry Man has used dairy products as far back as history records, and recent investigations have made clear the extent to which the human family has become dependent upon the cow

Relation of Dairying to the Fertility of the Soil It is conceded that the conservation of the fertility of the soil is the greatest problem of agriculture The fact is well known that without the extensive use of fertilizer, it is impossible to maintain the fertility of the soil where grain crops are sold from the farm Even granting this

is possible, however, it is certainly seldom done. So far, in our American history, grain selling has meant selling fertility that has been stored up in the past ages; and it has been followed by impoverished soils and unprofitable agriculture. On the other hand, we find farms in almost every locality—and even entire countries can be pointed out—where the fertility of the soil has been vastly increased by livestock farming. The most marked examples of this are connected with dairy farming, and the fundamental reason is shown by Table 3.

Table 3. Fertilizing Constituents and Value as Fertilizer of Material with Nitrogen at 20 Cents and Phosphorus and Potash at 5 Cents Per Pound

MATERIAL	LBS. NITROGEN	LBS. PHOSPHORIC ACID	LBS. POTASH	VALUE PER TON AS FERTILIZER
Corn fodder	25.0	6.0	16.4	$ 6.12
Timothy hay	25.2	10.6	18.0	6.37
Red clover hay	41.4	7.6	44.0	10.86
Alfalfa hay	43.8	10.2	33.2	10.83
Wheat straw	11.8	2.4	10.2	2.99
Corn	36.4	14.0	8.0	8.38
Oats	41.2	16.4	12.4	9.68
Wheat	47.2	15.8	10.0	10.73
Wheat bran	53.4	57.8	32.2	15.18
Linseed meal	115.6	36.5	27.8	26.33
Cottonseed meal	132.8	53.6	35.8	31.03
Milk	10.6	3.8	3.6	2.49
Cheese	90.4	—	—	18.08
Butter	3.2	—	—	.64

Important Soil Elements. *Of the ten or eleven chemical elements apparently necessary for plant growth, only three are liable to be lacking in sufficient quantities in the soil.* These are nitrogen, phosphorus—measured as phosphoric acid—and potassium—measured as potash. *The fertilizing value of barnyard manure depends upon the amount of these ingredients contained.* Commercial fertilizers used in enormous quantities in the older agricultural sections of the eastern and southern states supply one or more of these three elements in a form suitable for the use of plants. These commercial fertilizers have a well-established market value which depends upon their content of these three elements.

Farm crops also have a value as fertilizers, based, as in the case of commercial fertilizers, upon their content of nitrogen, potash, and phosphoric acid From the market price of commercial fertilizers may be calculated the market value of a pound of each of the three important elements mentioned By applying to the composition of crops the figures thus obtained, it is possible to calculate the cost of replacing the elements of fertility contained in a ton of these crops by purchasing commercial fertilizer at market prices The normal price for nitrogen ranges from 15 cents to 20 cents per pound, for potash and phosphoric acid, 5 to 8 cents per pound These prices are the same as used in Table 3

A study of this table makes plain the cause of the difficulty experienced in maintaining the fertility of the farm when the selling of grain crops is followed for a term of years Each bushel of wheat takes from the farm fertility that would cost 27 cents if replaced in the form of commercial fertilizer A bushel of corn removes fertility worth, on the market, 20 cents A ton of alfalfa hay sent to market carries with it fertility worth $9 05 on the market At times the farm prices for roughages is little more than the actual fertilizing value would be if purchased in the form of commercial fertilizer It should be stated, however, that with alfalfa clover and other legumes, the nitrogen comes largely from the air, and the *soil of the farm is not* depleted of nitrogen by selling these hays On the contrary, due to the accumulation of nitrogen in the roots this important element is increased in the soil when these crops are grown even if they are sold from the farm

Dairy products, however take but little from the farm in proportion to their selling value Milk carries from the farm about 10 *cents' worth of fertility in each 100 pounds and* taxes the fertility of the farm far more than does the sale of any other dairy product Even then at $2 a hundred for each dollar s worth of fertility sold in milk an *income of $12 60 is received while* with corn at 75 cents a bushel each dollar s worth of fertility brings only $2 65 when sold The sale of butter or cream takes from the farm so little of value as a fertilizer that it is hardly worth considering Since butter fat contains

only carbon, hydrogen, and oxygen, it has no value as a fertilizer. The only element of fertility in butter is the small amount of nitrogen contained in the curd, amounting in value to only 64 cents per ton, while the market value of this amount of butter at 60 cents per pound is $1,200.

Manure Value of Cow. A dairy cow weighing 1,000 pounds voids about 12 tons of solid and liquid manure in a year—worth, in round numbers, $28.00 at the market price of the three elements of fertility contained. Under proper management from 70 to 80 per cent of the manure voided by farm animals may be saved and returned to the soil.

The Ohio Experiment Station[3] obtained an actual value of $469 per ton for manure when applied at the rate of 8 tons to the acre in a five-year rotation. The average of all their extensive investigations showed an average value of $2.97 measured in increased crops grown, the price of crops in 1912 being lower than present prices.

The Purdue Experiment Station[4] reports crop increases worth from $2 to $8 with an average of $5 for each ton of manure applied, the variation depending upon the fertility of the soil and the rate of application.

But this does not tell all the story. The dairy farmer usually is a purchaser rather than a seller of grain, and by this means adds constantly to the fertility of his farm. The purchase of concentrated feeds rich in protein, as will be seen from the table, adds a large amount of fertility to the farm. Furthermore, the keeping of dairy cattle usually means that a large proportion of the land is kept in grass, consequently making it possible to prevent washing and erosion of the soil, which is responsible for the rapid deterioration of many farms.

It is a well-known fact that the yield of grain per acre of the agricultural lands of Denmark, Germany, and parts of England, where dairy farming has been followed for a period of years, has materially increased during the past fifty years.

[3] Ames and Gaither, Ohio Agricultural Experiment Station Bulletin 246 (1912).
[4] Wiancko and Jones, Purdue Agricultural Experiment Station Bulletin 222 (1918)

The Cow as a Producer of Cheap Human Food. Morrison[5] says, "Among all the animals of the farm, dairy cows of good productive capacity are unequaled as producers of human food."

The data in Table 4 show that the cow produces more human food from a given quantity of feed than is produced by any other farm animal. As producers of protein, hens are the nearest competitors of dairy cows, while as producers of energy the pig ranks second. However, both the hen and the hog require more concentrated food in proportion to the roughage than the cow, and in this way, except as consumers of waste products, they are hardly as efficient as the figures in the table indicate.

Table 4 Proportion of Food Eaten by Various Classes of Livestock That Is Returned for Human Use

ANIMAL	PER CENT OF PROTEIN RETURNED		PER CENT OF ENERGY RETURNED		
	Of Total Food	Of Digestible Protein	Of Total Food	Of Digestible Protein	Of Production Value of Food
Cow		41 0			48 9
Cow		31 4			40 6
Dairy herds	14 7	22 9	10 0	15 1	33 8
Steer		8 9			17 0
Steer	6 4	11 8	4 7	6 9	14 8
Hen	16 1	20 9	7 1	8 3	14 1
Poultry flock	14 5	18 6	6 4	7 5	12 6
Hog	10 2	13 2	15 1	17 5	29 9

Cow vs. Steer as Food Producer. Figures given in Table 5 have been compiled from data taken by the author to show the comparative production of food constituents by the dairy cow and by a high-class beef steer. The comparison is made of the milk produced by a high-producing Holstein cow in one year with the composition of the carcass of a fat steer weighing 1,250 pounds.

The total dry matter in the milk was 2,218 pounds, all of which in both edible and digestible The steer, with live weight of 1,250 pounds, contained 56 per cent of water in the carcass, leaving a total

[5] *Feeds and Feeding* 20th edition, p 478 Morrison Publishing Co., Ithaca, New York (1937)

of 548 pounds of dry matter. In this dry matter of the steer is included hair and hide, bones and tendons, organs of digestion and respiration; in fact, the entire animal, a considerable portion of which is not edible. The analysis of the steer's carcass was made from samples taken after grinding together one half of the complete carcass.

Table 5. Comparison of Food Constituents Produced by a Cow and a Steer

CONSTITUENTS	COW, 18,405 LBS MILK	STEER, WT. 1,250 LBS.
Protein	552	172
Fat	618	333
Sugar	920	
Ash	128	43
Total	2,218	548

The cow produced protein sufficient for more than three steers; nearly enough fat for two; enough ash to build the skeleton for three; and, in addition, 920 pounds of milk sugar worth at least as much per pound for food as ordinary sugar. In the comparison in Table 5 the cow used in this experiment was far above the ordinary and for this reason the following additional data calculated by the author are to show the amount of human food produced in a year by cows of ordinary productive ability.

Table 6 shows that these ordinary cows all produced more protein in a year than was contained in the carcass of a 1,250-pound steer. Three of them also produced more fat. The solids of all except two contained more ash than was found in the carcass of the steer. In addition, each cow produced from 290 to 437 pounds of sugar. The seven cows, representing three breeds, in one year averaged 970 pounds of total solids each, or nearly as much as was contained in the carcass of two steers.

A comparison of the feed consumed by the steer and the cows would be still more striking, since the steer required nearly two years of liberal feeding to build his carcass, and during the fattening period the ration was mostly grain. The product from the cows was made in less than one year, and largely from roughage. On the other hand, the dairy cow has to be fed two years before she comes into milk,

although when once mature she is productive for at least five or six years It is also recognized that the labor requirements in caring for the cow are much more than for the steer

Table 6 Milk and Milk Constituents Produced in a Year by Ordinary Cows

CONSTITUENTS	AVERAGE OF THREE JERSEYS LBS	AVERAGE OF TWO AYRSHIRES, LBS	AVERAGE OF TWO HOLSTEINS LBS
Milk	7 110	6 329	8,750
Protein	293	204	272
Fat	403	233	282
Sugar	312	311	406
Ash	53	39	59
Total solids	1 061	787	1 019

The Cow as an Efficient User of Roughage The special value of the cow as a domestic animal arises from her ability to consume and digest large quantities of roughage and to convert it into milk and meat suitable for the nutrition of man

The hog is a wonderful producer of meat, exceeding all other animals in regard to the amount of flesh produced from a given amount of feed, but the hog can use only limited amounts of roughage

The sheep can utilize coarse feeds to advantage, but other factors prevent the keeping of a sufficient number of them to use the immense quantities of roughage available

The production of large amounts of roughage is necessary in any good farm system and it is unavoidable in connection with the growing of crops The cow and the steer must be relied upon almost entirely to convert this into a form suitable for human food A considerable portion of the land in most agricultural sections is suitable only for pasturing on account of its being too wet or too dry, too hilly, or too rocky Such regions naturally develop a livestock industry On farms growing crops freely it is necessary to practice rotation of crops, resulting in quantities of hay and silage being available that can only be used by livestock of some kind, but best of all by cattle

Meat from Dairy Cows. Although cattle of the dairy breeds are kept primarily for milking purposes, they furnish nearly one half of the beef supply of the United States; and in addition they are the source of nearly all the veal that goes to market, amounting to more than nine million head annually.

As population becomes more dense and land values higher, a still larger proportion of the meat supply will come from dairy animals. This condition has long existed in Europe, where beef is primarily a by-product of dairying; and there is evidence that the same factors are at work in America. The fundamental reason for this is the greater efficiency of the dairy cow as a producer of human food and a steady source of farm income.

Dairying a Safe Business. One of the advantages of dairy farming which appeals to the farmer—especially a farmer with limited capital—is the quickness and the certainty of the returns. The dairy cow gives an immediate return and her product is always marketable. There is little of the element of speculation in this line of farming. The returns, while not large at any one time, are steady throughout the year and may be depended upon. The market price of dairy products, while sometimes unsatisfactory, varies on the whole less than almost any other class of farm products.

As a result of these conditions the development and expansion of dairy farming have in the past occurred with the greatest rapidity during periods of financial depression in agriculture. The general farmer at such times finds it desirable to produce sufficient dairy products to meet his daily needs for ready cash for current expenses at least.

THE LABOR QUESTION

The problem of securing sufficient and satisfactory labor is generally considered the greatest difficulty encountered in conducting a dairy farm. This difficulty arises from the necessity of treating the cow carefully at all times, and especially from the fact that the work becomes somewhat monotonous because it has to be done regularly every day. Although the labor problem is a serious one, it is no worse than that experienced in almost any other branch of farming; and, in

fact, under proper conditions and with modern equipment it may be less serious

Dairying a Year Around Job Dairy farming does require the constant attention of the owner or employees, but there are advantages as well as disadvantages to this situation A bricklayer working one half the year will seldom accumulate much property, neither will the farmer whose productive labor is confined to a few months out of the year, as is the case when a single crop is grown for market In the long run, the farmer, as well as the mechanic, who has work and who works throughout the year, at reasonable wages will prosper the most Dairying gives the farmer an opportunity to use his time regularly throughout the year Members of his family also find work adapted to their age and strength

The grain farmer crowds his work into a few months and requires a large amount of help for a few days or weeks only, and he finds this help almost impossible to secure, since he has no work to offer for the remainder of the year He has little reason to complain if an abundance of extra labor is not at hand for the short period he is willing to utilize it Labor on the dairy farm is distributed throughout the year, and arrangements may be made accordingly

Labor Dissatisfaction The objections raised by hired help to labor on the dairy farm are the long hours, the steady, regular work, and to some extent, the nature of the work itself—or rather the conditions under which it is done To reduce the labor problem to the minimum, first of all the hours must be made as reasonable as in other types of farming in the same community Arrangements should be made so that the milkers are through with their work as early as men doing field work Some provision must also be made for regular time off by each laborer in turn If the owner is doing his own work he should realize that he should follow the same practice himself and take some time away from his work, otherwise in time he will come to dread the monotony of it

The objections sometimes made to dairy work come almost entirely from the conditions under which the work is done If the cows are milked in a clean well lighted comfortable stable at reasonable hours, and if modern methods of handling the manure and feed by

overhead carriers or modern mechanical means are installed, the objections to the work will largely disappear. In most localities a man with a family, if provided with a comfortable house, may be employed by the year with satisfaction to both the laborer and his employer.

Increased Efficiency. While dairying has made greater strides in efficient production than almost any other type of farming, yet there are still great possibilities in more efficient production. Recent studies in rapid milking methods, new arrangement of barns, and bulk milk handling equipment have shown there is still much that can be done to reduce the cost of production of milk and increase the profit and satisfaction in dairy farming. The greatest hope for increased profits and prosperity in the dairy industry is to be found in the field of increased efficiency.

CHAPTER II

Origin and Classification of Domesticated Cattle

Origin of Cattle There are no cattle native to America All those found in North and South America are descended from animals brought mainly from Europe The domesticated cattle of Europe are descended from wild forms that originally lived in Europe and Asia Where and by whom cattle were first domesticated is unknown, as it took place in prehistoric times History is limited in this matter Within recent years considerable light has been thrown on the subject by extensive investigations regarding the early types of cattle and their relationship to the domesticated breeds of the present

The chief sources of knowledge regarding the original types and the place of origin are bones—largely skulls—found, usually, on the sites of dwelling places of prehistoric races These remains from different sources are carefully compared with each other and with corresponding specimens from various breeds and types of modern cattle and their near relatives from all parts of the world The ruins of dwellings used by the Lake Dwellers in Switzerland have yielded an unusually large amount of valuable material of this kind Ancient historical records and works of art which depict cattle have also been most carefully examined by those studying this problem The literature on the subject is large, but material gathered, while extensive, is so fragmentary that even those who have given the subject the most thorough study do not agree on more than the general details

Early Domestication. It has been established that cattle existed in Europe at least before the final retreat of the glaciers. According to Tyler,[1] the domestication of cattle probably took place near the beginning of the Stone Age, which he estimates to be 6000 B.C. Another authority, Gordon Childe,[2] believes that domestication of animals began about 10,000 years ago, "first apparently in the Near East."

Keller[3] believes that cattle were domesticated long before the records of history began—while the ancestors of the present Europeans still dwelt in Asia. About 6000 B.C., the ancestors of the Lake Dwellers of Switzerland are believed to have migrated from Asia, taking with them their domesticated cattle. Numerous remains of these cattle are found in the oldest ruins of the Lake Dwellers in Switzerland. These cattle, which were of the broad head and short-horned type, are believed to have been the first domesticated cattle and to have been related by early origin to the Banting or native wild ox of Asia, still found in small numbers on certain islands of the East Indies.

Original Types of Species. Although there is a wide divergence of opinion concerning the origin of domesticated cattle, most investigators of the subject agree that the cattle of Europe are descended from two original types or species. One is called the *Bos longifrons* by some authors, while other authors use the term *Bos sondaicus*. The second type is known as the *Bos primigenius*.

The Bos sondaicus type. Cattle of this type were brought into southern and eastern Europe during the great migrations that took place and were spread over the greater part of that continent. At that time these cattle were small in size and short-bodied, and had small horns. From this type, Keller believes that most of our breeds in use today are descended, including the Brown Swiss, Jersey, Guernsey, and all the breeds of England except the Longhorn and Scotch Highland. However, part of the English breeds—the Shorthorn and Ayrshire in particular—while having this type as a foundation, was

[1] *The New Stone Age in Northern Europe*, p. 94 Chas Scribner's Sons, New York (1921).
[2] *What Happened in History*, Gordon Childe, Penguin Books (1946).
[3] *Naturgeschichte der Haustiere*, pp 114–130 Paul Parey, Berlin (1905)

probably mixed in the early days of the breeds with the blood of the *Bos primigenius* type, through crossbreeding principally with Holland cattle

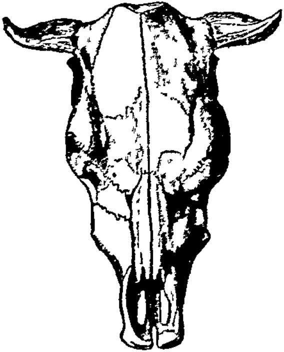


FIG. 1 Skull of *Bos longifrons* (*Bos sondaicus* Keller) Note the broad head and short horns This type is well represented by the Jersey breed

The Bos primigenius type This type, known as the Urus in the time of Cæsar, was an immense, powerful animal, standing six to seven feet high at the withers [4] The horns were long and slender, curving forward near the middle and ending with the points slightly upwards Historical records show that this form existed in a wild state in Europe until the twelfth or thirteenth, and possibly the fourteenth century This animal was apparently domesticated in northern Europe within historic times From it are descended the cattle of Holland and other parts of North Europe, the large, long-horned cattle of Hungary and adjacent regions, and the Longhorns and Scotch Highland breeds in England.

[4] Morse, U.S.D.A. Bureau Animal Industry 27th Annual Report, pp 181–239 (1910)

The most fundamental difference between the two original forms of cattle was the shape of the skull, and this difference is still evident in modern breeds. The *Bos primigenius* was characterized by a long, narrow head. This type of skull is well illustrated by the modern Holstein, whose long, narrow head is taken to indicate descent from the original long, narrow form. The remains of the *Bos longifrons,* or

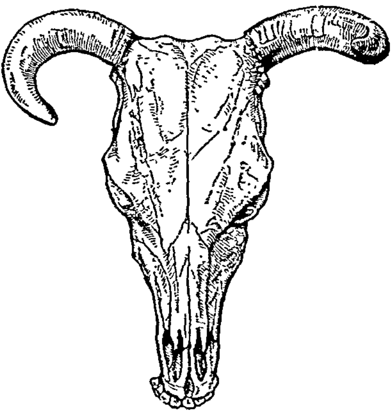


FIG. 2. Skull of *Bos primigenius.* Note the long narrow head. The Holstein is a good representative of this type.

the *sondaicus* type, show a broad short head, which characteristic is best illustrated by the short broad head of the typical Jersey, and which is found somewhat less marked in the Brown Swiss.

Origin of Breeds. A breed is a recognized further well-defined subdivision of a type or species. The number of breeds and sub-breeds of cattle is surprisingly great. On the continent of Europe alone between forty and fifty distinct breeds are described by German and French writers. Great Britain is the home of eleven breeds, which have been imported to the United States, and in addition to this as

many more minor breeds are described by English writers as of local importance

With few exceptions these numerous breeds have been long established, and historical records are not available to indicate their definite origin One exceedingly important factor, however, was the ancestry of the breed as between the two forms of wild cattle from which our present domesticated forms are descended This difference in origin is presumably the greatest factor in causing the wide differences between the Holstein and the Jersey breeds—these two representing better than other common breeds the two lines of descent from the original wild forms

Influence of Migration and Conquest Another factor in the formation of breeds was the conquest of one country by another, as the result of which a new mixture generally resulted from the cattle introduced by the invaders In the early historical times whole peoples migrated at times for long distances, taking their cattle with them For example, the Simmenthaler breed in Switzerland reveals the same characteristics of skull as found among the original cattle of Sweden, from which localities the Burgundians are supposed to have migrated about A D 400

Next to these two factors already mentioned come conditions of environment, such as climate, food, and topography of the country In early times, with no organized means of transportation, little exchange of animals took place from one locality to another except as in the cases mentioned, when a whole people migrated or conquerors brought in a new type of animal In these times there was little if any attempt at improvement The effects of natural conditions were allowed to work out almost undisturbed by the selection of man, and characteristics became fixed Types formed by such means may be called natural types or breeds

Birth of Art of Breeding Up to about 1770 these natural conditions and the introduction of new types by the means of conquest and migration as previously noted, were the chief factors in the development of distinct types Beginning about 1770, a great interest was aroused in England in the improvement of the quality of cattle and other domestic animals of Great Britain This exceedingly im-

portant movement, known as the art of breeding, seems to have started largely as the result of the work of Robert Bakewell.[5] This pioneer in the art of breeding began active operations about 1760 and continued until his death in 1795. The activities of the Collings brothers in improving the Shorthorn breed, beginning about 1780, rank next to those of Bakewell in calling public attention to the possibilities of livestock improvement. The remarkable movement initiated by these two men for the improvement of domestic animals spread over Great Britain and influenced the entire civilized world as well; the beginning of modern improved breeds is to be traced back to it.

The Principles of Livestock Improvement. The methods developed and emphasized by these pioneer breeders are essentially the same as those followed today: careful selection of breeding animals, liberal feeding, and general good management. Bakewell was the first to understand and practice inbreeding and line breeding as means of fixing desirable characteristics. A certain amount of crossing was also done in the early history of some breeds—with the Ayrshire and the Shorthorn, for example.

At the present time the efforts of cattle breeders are directed toward further improvements in the breeds already in existence and not towards the establishment of new breeds. The reason for this is the realization that breeds are now in existence which are adapted to practically any conditions under which cattle may be profitably kept. Furthermore, to develop a new breed with as well-established characteristics as those already in use would require more than the lifetime of a man, and would not be financially remunerative. There is every indication that we will have fewer breeds in the future.

Inheritance Value of Breeds. The breed is only one of many factors to be considered in carrying on profitable milk production. In some cases the value of the breed is overestimated, but more often the reverse is true. Our present dairy breeds represent the efforts toward improvement in certain definite lines made by several generations of breeders. It would be folly for a man to attempt to start at the beginning to build up for himself what has taken a century or

[5] *Journal Royal Agricultural Society of England*, 55 1–31 (1894).

more for others to build By making use of animals of a highly developed breed, adapted to the purpose for which they are to be used, he is taking advantage of all the work that has been done and starting at the highest point of advancement reached by other breeders

So-called pure breeds have been bred for generations with certain objects in view, and in the course of time these characters become fixed as breed characters, and are transmitted It is easy to understand why the chances are good for getting a good dairy cow if the ancestors are the Holstein—known to have been bred about 2,000 years in one locality and noted for hundreds of years as great dairy animals—or if the parents are Jerseys, bred for 500 years, or longer, along one line

Market Value of Breeds Cows of a distinct dairy breed usually —and rightly—sell for more than the same number of cows of mixed or unimproved breeding, even if the latter are known to be equally good as dairy cows The cows of a distinct dairy breed are worth more to the buyer, because he can reasonably expect these animals to show the typical character of the breed to which they belong, in production of milk, in disposition, and in other breed characters A cow of mixed breeding, even if a good dairy cow or an unusually good milker in a breed where milking qualities are not generally found, cannot be counted upon to reproduce herself in her offspring It is a well known fact in animal breeding that the longer the certain character has existed in a breed, the more certain it is to be transmitted

Classification of Cattle Various classifications of cattle have been made, some based upon geographical distribution (as lowland and mountain cattle), others upon their anatomy (especially the shape of the skull), and others as to their domestic use Today most American writers arrange them according to the economic value as beef breeds, dairy breeds, and dual purpose cattle

No system of classification has yet been devised that can be applied in more than a general way to the individuals that make up the great mass of cattle If we undertake to arrange them by breeds, we find, in addition to the recognized breeds animals with all possible mixtures of the blood of two or more breeds, or with more or less improved

blood mixed with the scrub, or unimproved. If we should attempt to arrange them according to the purpose for which they are adapted or kept, we would have a constant gradation from the extreme beef to the extreme dairy development.

It is difficult even to arrange a suitable classification of the breeds, since the animals may vary greatly within a breed on account of environment and treatment. The following descriptive terms are in common use:

Scrub. A scrub is an animal of mixed or unknown breeding, without the type or markings of any recognized breed. Other terms used with practically the same meaning are native, mongrel, or unimproved, as well as other names of a local character, such as "piney woods." These terms generally indicate that the animal does not carry more than at least a small amount of the blood of any of the improved breeds. Typical scrubs are not numerous except in those sections where very little attention is given to cattle raising. The term "scrub" is often applied also to inferior or unhealthy animals of recognized breed type.

Crossbred is a term used to indicate that the animal is the offspring of parents of distinct breeds, either high grades or purebred

Grade. This term is generally used with a certain breed name, as Grade Jersey or Grade Shorthorn This means that the animal in question has half or, usually, more of the blood of the breed mentioned. When the proportion of the pure blood is large, the animal is called a "high grade." The proportion of the blood predominating may be so great that for all practical purposes the animal is the same as a purebred; but it cannot be called a purebred, no matter how many crosses have been made, and such animals cannot be registered in most of the various herd books.

Purebred. The term "thoroughbred" is often improperly used for the proper term, "purebred." The term "thoroughbred" is properly applied only to the well-known English breed of horses Purebred cattle, as understood in America, are those whose ancestors came from the native home of the breed in question and conformed to the requirements of this breed here. This blood must have been kept pure and unmixed since importation, and records must be available show-

ing the descent from these imported ancestors The records of descent of these animals are kept in a systematic manner by associations formed for the purpose by those interested Much undue importance is often given to the term "purebred" In the strict interpretation of this term no animal is "pure," as it is well known that all present recognized breeds are the results of the crossing and mixing of many types of cattle in the countries where the breed first developed

The breeds of cattle common in America are usually classified as dairy, dual-purpose, and beef.

DAIRY BREEDS	DUAL PURPOSE	BEEF BREEDS
Holstein	Shorthorn	Shorthorn
Ayrshire	Red Polls	Hereford
Jersey	Polled Durham	Aberdeen Angus
Guernsey	Devon	Galloway
Brown Swiss		

In addition to the above, small numbers of French-Canadian, Dutch Belted, Kerry, Red Dane, and polled Jersey cattle, all to be classed as dairy breeds, are found in certain localities of America.

CHAPTER III

The Dairy Type

There is but one entirely satisfactory way to select cows for dairy purposes, and that is by records of production of each individual, as determined by the use of scales and the Babcock test. Official testing of purebreds and work by dairy herd improvement associations have made commendable progress during the past quarter of a century; but there are still vast numbers of cows used for dairy purposes on which no tests for milk and butterfat production have ever been made. In determining the value of such animals for dairy purposes, the estimate must be based upon conformation, or the degree to which the animal approaches what is known as the dairy form or type. While such estimates may be very inaccurate, the excessive development of the function of milk production through generations of selection and breeding in that direction has brought about certain characteristics in the conformation of the animal that may be fairly reliable in judging the development of these functions.

The breeders on Jersey Island are generally credited with formulating the first scale of points for dairy cattle in 1834. The breeders' associations have prepared for each breed a carefully drawn scale of points that are of assistance in acquiring a skill in the selection of cows by conformation. A scale of points undertakes to describe the conformation of the animal that, in the judgment of the author, denotes the highest development of the characteristics sought. The comparative importance of the parts described is represented by points that total 100 for the perfect animal. The lack, up to the

present time, of a really scientific basis for preparing a scale of points makes them unsatisfactory in many ways, but of great general value, especially to the beginner

The General Characteristics of the Dairy Type "Type," in this connection, refers to the conformation of the animals which indicates or suggests the purpose it serves A person familiar with cattle in general, but not with highly developed dairy cattle, looking for the first time upon a high-class dairy cow in full flow of milk would have his attention especially directed to three points as follows

1 The extreme angular form, carrying no surplus flesh, but showing evidence of liberal feeding and growth by a vigorous physical condition
2 The extraordinary development of the udder and milk veins
3 The marked development of the barrel in proportion to the size of the animal

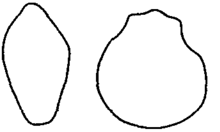


FIG 3 Cross-sections of a high-class dairy cow at the heart girth and the paunch Correct dairy form shows a series of angles rather than smoothness.

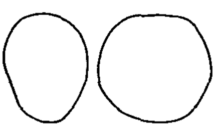


FIG 4 Cross-sections of a high-class fat steer at the heart girth and the paunch Contrast the smooth round withers and loins of the steer with the angularity of the cow in these parts

These three points should be kept in mind as describing the special characteristics of the dairy animal in comparison with those bred for beef, or with *inferior dairy animals* *Sometimes* the error is made of attributing this lack of flesh, so characteristic of a good dairy cow, to insufficient feeding The dairy cow does not, however, have the same appearance as an animal not of the dairy type that is in thin flesh on account of insufficient feed A high-class dairy cow never carries much flesh when in full flow of milk The stimulation to produce milk is so strong that all the feed she can consume and digest above that needed for maintenance is *utilized in producing milk* Such an animal, al-

though thin in flesh, has an alert, vigorous appearance, her hair is soft and healthy, her skin is pliable and loose, her eyes are bright, her paunch is full, and a general appearance of thrift and contentment is noticeable. An animal thin in flesh on account of insufficient food has a stupid appearance and shows a lack of vigor, while the rough, long hair stands on end. The paunch may be large or not, depending on the bulkiness of the feed consumed by the animal.

The Dairy Form. The modern high-producing dairy cow is a result of selective breeding. This means that her ancestors have proved their productive ability and that they approach the breeder's ideal of good dairy form. Their function has been to produce large quantities

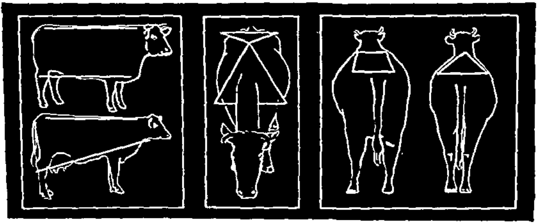


FIG. 5. The body form of the dairy cow should be wedge-shaped, while that of a beef animal is rectangular (Cushman, Clemson College, South Carolina, Extension Bulletin 78, p. 9, 1936.)

of milk, and observant breeders have found that this function demands that the animal be so formed that she has the bodily equipment to carry on the work of milk secretion. Breeders have found that certain characteristics of form are always associated with high productive ability, and they consider these features in selecting their breeding stock. First among them is the general shape of the animal.

The dairy conformation. The body of the dairy cow should be angular in shape as viewed from the front, the side, and over the top or withers. The angularity or sharpness of points has been commonly spoken of as the wedges. Angularity and sharpness of withers are associated with dairy production and are in contrast to the fleshy, well-rounded, and rectangular form as found in the beef type.

Dairy temperament It should be understood that it is natural for any cow to fatten somewhat toward the end of her milking period and when dry This surplus fat is taken from the body mostly during the first three or four weeks after calving *It is impossible to fatten a* high-class dairy cow with any ration during the best part of her milking period, or even to keep the fat that is on her body at calving time from being removed during the first three weeks she is in milk

The cow that shows these characteristics to a marked degree is said to have a good dairy temperament This means she is endowed by nature with a strong stimulation to produce milk, and uses practically all the nutrients she can digest for milk production This accounts for the spare form and absence of any surplus fat, even when the animal evidently has abundant food As a result of the above, a high-producing cow when in milk is usually thin and sharp over the withers, her backbone strong and prominent, and her hips and pelvic region stand out almost free from flesh

When the cow is dry, or nearly so, she should carry more flesh than when in full flow of milk, and she should not be criticized on this account The breed type should be taken into account as well, and the mistake avoided of judging all by the same arbitrary standard

Types of Cows Fig 6 is a good illustration of a cow lacking in dairy temperament, although she is a purebreed animal of one of the leading dairy breeds This animal has a capacious barrel and an unusually large heart girth She lacks the stimulation necessary to use her food for producing milk This is shown by her lack of udder, thick withers, thick covering of flesh over the back, and general smooth, beefy appearance Fig 7 illustrates the other extreme This cow has so strongly developed the tendency to produce milk that she uses the greater part of all the food she can eat and digest for this purpose and carries no surplus flesh Her withers are thin and sharp, and her back and pelvic region angular and bony Her udder is also well developed

A cow should be expected to carry somewhat more than her normal flesh for a short time after calving, but this beefy appearance should disappear within a month or less

Limitation of Selection by Type. The selection of dairy cows by type, as indicated, is often uncertain. Still, the practical breeder or dairyman must select most of his animals in this way. The limitation should be understood. Anyone familiar with dairy type will seldom fail to choose correctly between a high-class animal and an inferior one—as, for example, between the cow shown in Fig. 6 and that in Fig. 7. Usually it is easy to choose between a cow producing

FIG. 6. A purebred Jersey cow. She is a vigorous, healthy animal, but lacking in dairy conformation and dairy temperament. Average record of four years was only 2,501 pounds milk and 122 pounds of fat.

350 to 400 pounds of butterfat in a year and one producing 150 pounds. However, as between the good and the extraordinary cow, type gives little upon which to base selection.

One seldom sees a cow of extraordinary dairy quality that does not conform to the descriptions given in the following pages. While in some cases cows may fail to score high on account of not conforming to the score card in some particular point (for example, on account of a weak fore udder or a sloping rump), they show the important characteristics of good dairy type. If a dairy cow is to be judged with any accuracy, she must be in milk, and preferably near

the best stage of her milking period A dry cow offers in most cases very little upon which to base judgment A dairy cow thin in flesh from underfeeding is also in a condition that makes it almost impossible to form an estimate of her value

Development of the Barrel The dairy cow that is a heavy producer must have large organs of digestion in order to utilize the enormous quantities of feed necessary to produce large quantities of

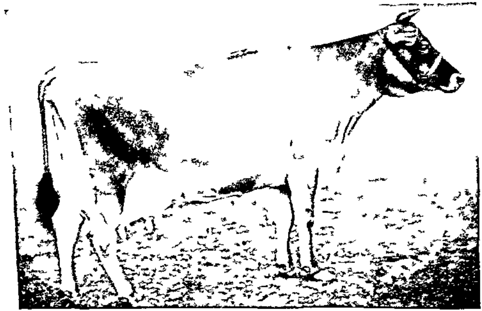


FIG. 7 A typical dairy type This cow shows excellent udder dairy temperament, and body conformation

milk This results in the development of a large barrel, as that part of the animal's body between the fore and rear legs is commonly called A high producing cow has wide-sprung ribs far apart The ability to lay three fingers of the hand between the ribs is an accepted measure She should have a deep abdomen, giving great capacity for the digestive tract and other vital organs An animal lacking in this barrel capacity cannot use sufficient feed to be a large producer The age of the animal has some influence on the size and depth of the abdomen The depth of the barrel naturally increases somewhat with the age of the cow The feeding of a ration consisting mostly of bulky

feeds, as hay and silage, also tends to give the appearance of greater barrel capacity from the greater contents of the digestive tract In considering the barrel development of a cow, the depth as viewed from the side should be observed, then the width as viewed from behind Some animals show a great depth, but on account of being narrow have no more real capacity than another animal with less depth, but greater width

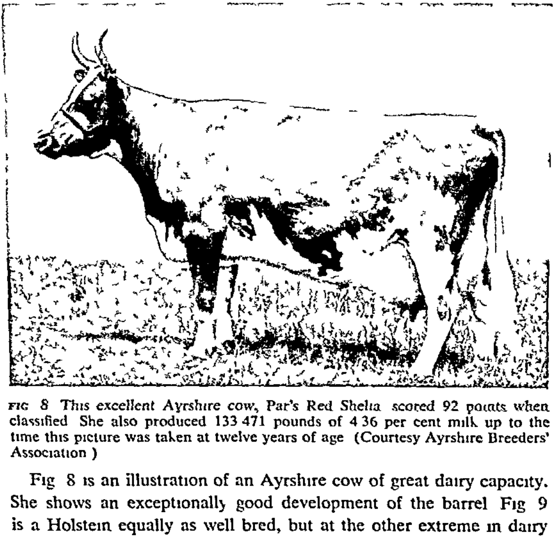


FIG 8 This excellent Ayrshire cow, Par's Red Shelia scored 92 points when classified She also produced 133 471 pounds of 4 36 per cent milk up to the time this picture was taken at twelve years of age (Courtesy Ayrshire Breeders' Association)

Fig 8 is an illustration of an Ayrshire cow of great dairy capacity. She shows an exceptionally good development of the barrel Fig 9 is a Holstein equally as well bred, but at the other extreme in dairy capacity. She shows an unusually small development of the barrel, in keeping with her inferior dairy qualities

Circulation After the food is digested and absorbed into the circulation, it must be carried to other organs of the body and undergo many changes before it is secreted in the form of milk A strong,

active circulation is of great importance, since without it the whole organism lacks tone The circulatory system includes the heart, lungs, arteries, and veins A large heart girth is usually assumed to indicate a large capacity of the heart and lungs There is, however, some question as to the relation between body measurements and milk production Gowen[1] found some definite correlation between milk

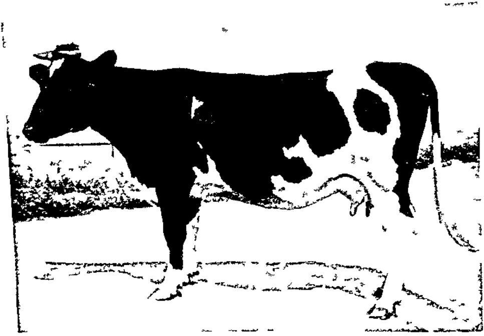


FIG 9 A very poor type Shows lack of capacity and dairy temperament Also poor breed characteristics A cow of this type should be avoided

production and live weight, body length, body width, and body girth, but little correlation between milk production and height, hip and thurl width, or rump length A soft, pliable skin seems also an indication of a good circulation When the animal has good "handling qualities," it means the small blood vessels below the skin are active and that the animal is in good health A clear, bright eye also indicates a good circulation When the cow is sick, or is by nature dull and sluggish, circulation is poor and the skin feels dry and hard, with rough upstanding hair, and her eyes lack luster

[1] Gowen *Milk Secretion* p 41 Williams and Wilkins Co Baltimore (1924)

The Milk Veins and Milk Wells. The most important point to be observed regarding the circulation is the development of the milk veins. The blood, after supplying the udder with material for milk secretion, starts back towards the heart through the milk veins. One of these opens on either side near the front line of the udder attachment to the body, and passes forward just beneath the skin. These veins crook back and forth more or less, in some cases divide into two or more branches, and finally pass upward through one or more openings in the wall of the abdomen into the body cavity. The portion of the vein from the udder to the opening through which it passes into the abdomen is called the milk vein. The opening in the abdomen through which the vein passes is popularly known as the milk well. Fig. 10 shows exceptionally good development in this respect. The milk vein has long been one of the indications of dairy capacity, since a large production of milk calls for a large quantity of blood to pass through the udder, and a large milk vein has been thought to indicate such a circulation. The exhaustive work of Swett[2] indicates the fallacy in some of these earlier assumptions. The size of the milk vein is influenced to a great extent by the age of the cow. In a young animal the vein is smaller and more elastic than in the aged cow. When a cow is producing the maximum amount of milk, the veins are larger than in the case when the same animal is dry. The milk wells remain practically a constant size after the cow is mature.

The Udder. The development of the udder, especially in regard to its size and shape is of the greatest importance in selecting a cow. In the manufacture of milk, the food of the cow is first digested, then absorbed into the blood, which passes by circulation to the udder. The udder consists of two large glands which are more or less distinctly divided to correspond with each of the four teats. The duct of each teat enters a small cavity called the milk cistern. The main body of the udder is made up of glandular or secretory tissue, connective, and fatty tissue. Since this gland is responsible for the secreting of milk from the blood, its size and development are the most important of all as indicating the dairy qualities of the cow. Fig. 11 illustrates differences in good udder formation.

[2] Swett, U.S.D.A. Yearbook Separate No. 1909 (1947).

It is not the size of the udder alone that is important, but the number of active secreting cells An udder gland filled with inert cells and fatty tissue is not effective This is illustrated by the meaty udder in

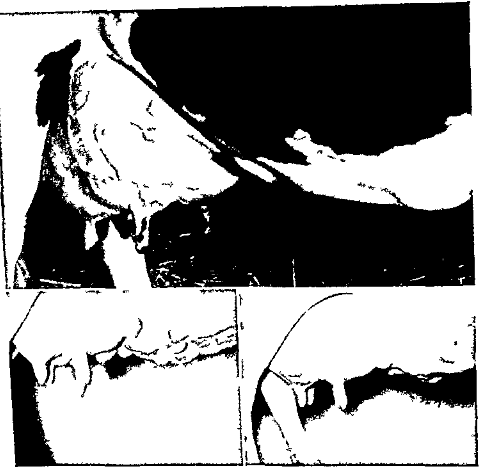


FIG 10 Well-developed mammary veins The size of the milk veins leading from the udder and the veining on the udder are regarded as excellent indications of the milk producing ability of the cow (Courtesy Michigan State College)

Fig 12 This is a large well formed udder, but the cow in this case was a very moderate milker Such an udder is nearly as large after milking as before The best type of udder has a long attachment to the body, both in front and behind A good circulation of blood and healthy tissue are indicated by the soft, pliable skin and prominent

An almost perfect udder that has produced 40 tons of milk

A well balanced udder with excellent length of attachment

An udder showing excellent size and symmetry

Showing quality and veining

FIG. 11 Well-developed udders. Cows that rank high in milk production always have large and usually well-developed udders

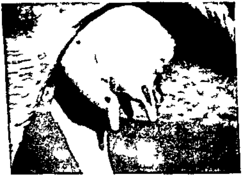
veins. Before milking, the udder is naturally and considerably extended; after milking, it should be greatly reduced in size and show an abundance of loose skin and a soft, pliable texture. Fig. 11 shows fine examples of well-balanced udders.

The attachment of the udder to the body in the rear should extend well up behind and have good width. Special attention should be given the fore udder, as this part of the gland is especially subject to in-

complete development It should join the abdomen well forward and be well up with the floor of the udder level Fig 12 illustrates defective udders The quarters should be even in size, without deep indentations between The teats should be of proper size for convenient milking and evenly placed

A weak fore udder

A pendulous oversized udder



A badly quartered udder poorly shaped teats

A meaty poorly shaped udder

FIG 12 Common udder defects A well-developed udder is of first importance in selecting any dairy cow Defects are common in all breeds

For show purposes especially, the shape and symmetry of the udder are particularly important From the standpoint of production the essential thing is to have sufficient udder capacity to admit the secretion of a large amount of milk with teats of such size as to admit convenient milking When a cow is dry it is impossible to judge accurately the development of her udder However, a large number

of loose folds of skin, showing an abundance of room for expansion when the udder is filled, may be taken as an indication that the udder will develop in a satisfactory manner. When judging a dry cow, length of the attachment to the body should be especially noted. But little can be judged regarding the future and shape of the udder in the calf or heifer until the time of calving approaches. The size and placing of the teats may be observed and judged with more accuracy than can the future development of the udder.

Other Features. Size and shape of the body and udder are the most important points to consider in selecting dairy cows, but dairy type and temperament are also indicated elsewhere. Fine, clean-cut features about the face and head; wide muzzle and open nostrils; prominent, bright, active eyes; long, thin neck, lacking thickness or coarseness at the throat, and joined smoothly to the shoulders; fine, smooth withers; prominent and strong backbone; roomy pelvic region and hip- and pin-bones wide apart; thighs thin and incurving, with plenty of room between for udder development; and fine, clean bone throughout—all are features associated with cows of pronounced dairy temperament and large productive ability.

Breed Type. This term ordinarily embraces most of the foregoing characteristics indicative of temperament and capacity, and includes a number of other points which appeal to the eye, such as the long level rump, straight top lines, shapely udder, well-dished or clean-cut face, and large, prominent eye. All these features are desirable, and are found in the good representatives of the various breeds, but they do not of necessity contribute very much to the productive capacity of the animal.

The Score Card. The score card, as applied to dairy cattle, is a concise description of the conformation of body desired with a numerical expression of the relative importance of each point considered. Perfection is, in most cases, represented by 100 points.

The first atempt to formulate a score card seems to have been made by the breeders on Jersey Island about 1834. The first score card carried only 26 points. When the importations of Holstein cattle to America began in the early seventies, the breeders of Holland also published a scale of points for their cattle. The American Jersey

Cattle Club first published a score card in 1889 and the Holstein-Friesian Association of America in 1885. In both cases there were modifications and improvements of those originally developed by the European breeders The other breed associations later adopted score

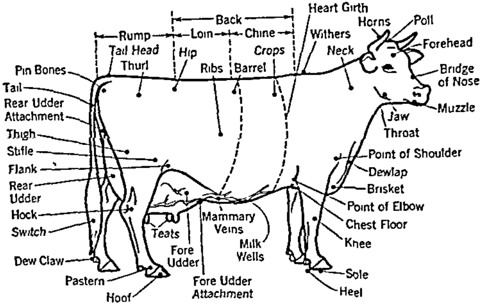


FIG 13 Points of a dairy cow The student of dairy cattle should know the descriptive terms used in judging

1 Muzzle
2 Nostril
3 Jaw
4 Breadth between eyes
5 Forehead
6 Poll
7 Throat
8 Dewlap
9 Neck
10 Withers
11 Shoulder
12. Brisket
13 Chest
14 Heart girth
15 Crops
16 Loins
17 Hips
18 Thurls
19 Tail setting
20 Pin bones
17–20 Rump
21 Escutcheon
22 Thighs
23 Rear attachment of udder
24 Rear udder
25 Switch
26 Hocks
27 Stifle
28 Flank
29 Fore udder
30 Mammary veins
31 Mammary wells

cards suited for their purposes The score cards as now recommended by the several different dairy breed associations may be secured from them

The student should bear clearly in mind that in the formulation of the score card, consideration was not given to milk production alone Breed type—that is, the conformation which is desirable from the

standpoint of appearance—also received a considerable share of attention. It is clear in some cases that still another point was given attention. Certain breeds tend to be deficient in certain respects—for instance, the Jersey breed in the fore udder—and it was hoped that through emphasizing the value of such points by assigning a rather large value, the defect would be gradually eliminated from the breed.

As indicated, certain points of conformation—for example, the large development of the udder and barrel and a general evidence of using the feed for milk rather than for flesh production—clearly have to do with a capacity for milk production. On the other hand, there is no evidence that level rump and the dished face of certain breeds are correlated with milk production. These points are emphasized from the standpoint of appearance; having to do with a pleasing appearance they are none the less desirable, but it should be clearly understood that most score cards, especially those developed by the breed associations, look to both utility and beauty of form.

Use of the Score Card. While there is ample ground for a difference of opinion concerning the make-up of the score cards in use, their value—for the beginner particularly—is unquestioned. The use of the score card is especially valuable as a means of impressing the points to be taken into account and their relative importance. Their value decreases as experience is gained. Before using the score card the student should be familiar with the points of the animal as described in Fig. 13. After the student has progressed to the point of being reasonably familiar with judging, the score card is best discarded and the judging done by comparison alone. Judging of cattle in the show ring is done entirely by comparison.

Since the essential facts concerning dairy type are much the same regardless of breed, it has been a common practice in teaching the judging of dairy cattle to make use of a general score card which aims to present the points of conformation indicating a high development of dairy quality regardless of particular breed characteristics. The beginner may well start with a score card of this type, making a study of dairy type in general. Later the breed score cards should be used and attention directed towards the points most emphasized. The score card given is the standard score card used for a study of the dairy type in general.

Unified Score Card for Dairy Cows*

(APPROVED BY THE AMERICAN DAIRY SCIENCE ASSOCIATION, 1943)

BASED ON ORDER OF OBSERVATION		PERFECT SCORE
1. *GENERAL APPEARANCE*		30
Attractive individuality, *revealing vigor, femininity,* with a harmonious blending and correlation of parts Impressive style and attractive carriage with a graceful walk		
BREED CHARACTERISTICS	12	
HEAD—medium in length, clean-cut, broad muzzle with large open nostrils, lean, strong jaw, full, bright eyes, forehead broad between the eyes and moderately dished, bridge of nose straight ears *medium size and alertly carried*		
SHOULDER BLADES set smoothly against chest wall and withers, forming neat junction with the body		
BACK *strong and appearing straight with vertebrae well defined*		
LOIN broad, strong and nearly level	10	
RUMP long, wide, *top-line level from loin to and including tail head*		
HIPS wide, approximately level laterally with back, free from excess tissue		
THURLS wide apart.		
PIN BONES wide apart and slightly lower than hips well defined		
TAIL HEAD *slightly above and neatly set between pin bones*		
TAIL long and tapering with nicely balanced switch		
LEGS wide apart, squarely set, clean-cut and strong with fore legs straight		
HIND LEGS nearly perpendicular from hock to pastern When *viewed from behind, legs wide apart and nearly straight* Bone, flat and flinty, tendons well defined Pasterns, of medium length strong and springy. Hocks cleanly moulded	8	
FEET short and well rounded, with deep heel and level sole		
2 *DAIRY CHARACTER*		20
Animation, angularity, general openness, and freedom from excess tissue, giving due regard to period of lactation		
NECK long and lean, blending smoothly into shoulders and brisket, clean-cut throat and dewlap		
WITHERS well defined and wedge-shaped with the dorsal processes *of the vertebrae rising slightly above the shoulder blades*	20	
RIBS wide apart Rib bone wide, flat and long		
FLANK deep arched, and refined		
THIGHS incurving to flat from the side wide apart when viewed from the rear, providing sufficient room for the udder and its attachment		
SKIN of medium thickness loose and pliable Hair fine		
3 *BODY CAPACITY*		20
Relatively large in proportion to size of animal, providing strength and vigor	12	

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Unified Score Card for Dairy Cows (*Continued*) *
(APPROVED BY THE AMERICAN DAIRY SCIENCE ASSOCIATION, 1943)

BASED ON ORDER OF OBSERVATION		PERFECT SCORE
BARREL deep, strongly supported, ribs wide apart and well sprung depth and width tending to increase toward rear of barrel	—	
HEART GIRTH large resulting from long, well sprung forenbs wide chest floor between front legs, and fullness at the point of elbow	8	
4 *MAMMARY SYSTEM*		30
A capacious, strongly attached well-carried udder of good quality, indicating heavy production and a long period of usefulness		
UDDER—CAPACITY and SHAPE long wide and of moderate depth Extending well forward strongly attached reasonably level floor Rear attachment, high and wide Quarters evenly balanced and symmetrical	25	
TEXTURE soft, pliable, and elastic Well collapsed after milking		
TEATS uniform, of convenient length and size cylindrical in shape, free from obstructions well apart and squarely placed plumb	—	
MAMMARY VEINS long, tortuous, prominent, and branching, with numerous large wells Veins on udder numerous and clearly defined	5	
TOTAL		100

CHAPTER IV

Holstein-Friesians

Origin and Distribution in Europe. This breed originated in Holland, and more especially in the province of Friesland. It is not, as the name would indicate, native to the duchy of Holstein, which is a province in North Germany. The compound name Holstein-Friesian, the official name of this breed in America, resulted from a union of the Holstein Breeders' Association and the Duch Friesian Association in 1885. In common usage now in America the breed is generally called Holstein.

The ancestral type of the breed, according to Keller, was the *Bos primigenius*, the wild ox of Europe. The breed is one of the oldest in existence. Historical references indicate that these cattle have been bred in the same region for 2,000 years or more and probably there has been only limited mixing with outside blood. In the time of Cæsar the region now part of Holland was famous for its cattle. In the ninth century Holland was well known for its cheese and butter. According to Motley, Holland in the seventeenth century exported annually large quantities of butter and cheese, and was noted for its immense oxen. This reputation has been maintained ever since, and during these centuries cattle rearing as has been almost the exclusive business of the Holland farmer. Today but little fruit is grown and very little grain. The caring for cows, the growing and preparing of feed for them, largely pastures and grasses, and the utilizing of milk for butter and cheese manufacture monopolize the attention of the farmers.

Influence on Other Breeds. The Holstein-Friesian breed is best developed in its native home, the province of Friesland and across the Ijsselmeer in North Holland. It has been the parent stock of several others, which through local influences have been modified from the original. Most prominent among these descendants are the Oldenburg, East Friesian, East Prussian-Holland, Jutland, and the Flanders of Belgium.

The Holland cattle, or their descendants in these latter mentioned sub-breeds, are now distributed over a large portion of North Europe, extending into Russia. In the seventeenth and eighteenth centuries, Holland cattle were taken to England, where, according to Professor Low, the eminent English authority, they were a factor in the formation of the Teeswater or Shorthorn breed, from which our modern improved Shorthorns are descended. It is also believed by good authorities that Holland blood was an important factor in the foundation stock from which the present Ayrshire breed is descended.

Conditions in Holland. The best part of Holland lies almost entirely below the level of the sea, which is kept out by enormous dykes. The land is very fertile, and is almost exclusively used for growing grass. The farmers, who are mainly tenants, pay from $30 per acre upwards annual rent. The land, which is seldom bought or sold, is valued at from $800 to $2,000 per acre.

In no other part of the world does the cow receive such careful attention as in Holland. About the first of October the cattle are placed in the stable, which is often separated only by a door from the living room of the family, and remain there, constantly as a rule, until the first of May. The stables and the cows are kept in a condition beyond criticism from a sanitary standpoint. If an animal becomes soiled with manure, she is washed and cleaned carefully before milking. The feed is mostly hay and grass silage, with a small allowance of linseed or other cake.

In the summer season the cattle are kept on the pastures and not brought to the barn. Pasture rotation is practiced and Holland has the best pastures in the world. The milkers carry the milk from the pasture rather than fatigue the cows by driving them. If a cold wind blows up, the cows are at once blanketed in the pasture. Great care is

taken in raising stock from only the best animals. Only a few bulls are raised, heifers are rigidly culled and only those from the best milkers are raised. The surplus calves are sold for veal, and the old cows as a rule are sold for beef at an age of eight or nine years. In Friesland the milk is largely for butter-making and in North Holland mostly for cheese making.

Importations and Distribution in America. A few Holsteins were imported into New England as early as 1795, but were not kept pure. The first importations that were kept pure were brought into Massachusetts in 1861.[1] Only a few were brought over before 1875, but between this date and 1885 about 10,000 were imported, and from these are descended most of the animals of this breed now in America. The only animals imported since 1885 were a few in 1903, and a few by way of Africa and England in recent years. The explanation of the small number imported lately is the high fee required by the Holstein-Friesian Association for registering imported animals and the almost constant prevalence of foot-and-mouth disease in Holland, which has resulted in a quarantine most of the time during the past half century.

It is estimated that there are approximately 1,000,000 living registered Holsteins in the United States. The five leading states in numbers are New York, Wisconsin, Pennsylvania, Ohio, and Michigan. The numbers in the southern states are limited. The distribution of grades of this breed, as with other breeds, coincides with that of the purebreds. There are entire counties in New York and Wisconsin where few animals of any other breed are to be seen.

Breed Organizations. The first breed association, known as the *Holstein Herd Book Association*, was organized in 1873, and five years later the Dutch Friesian Association of America was formed. In 1885 the two united under the name Holstein-Friesian. The registration of Holsteins increased with great rapidity from 1900 to 1920. They have continued to be a popular dairy breed. Up to 1955 the total number registered was 5,200,000. Of these about one third were bulls. Registration for 1954 was 195,963. More than 1,000,000 have been registered in the last six years.

[1] Houghton, *Holstein-Friesian Cattle*, p. 17. Press of Holstein-Friesian Register, Brattleboro, Vt. (1897).

Size and Type. The Holsteins are the largest of the dairy breeds. The desired average weight of the mature cow is 1,300 pounds, although individuals vary from 1,100 to 1,800 pounds. The bulls vary, as a rule, from 1,800 to 2,200—occasionally an individual reaches a weight of 2,500 or even more. The tendency to a somewhat larger type has been encouraged by the fact that the cows holding the largest official records are in practically every case far above the average of the breed in size. Some of the best-known cows of the breed in recent years have weighed 1,800 or in a few cases over 2,000 pounds.

In the description found in the early volume of the Advanced Register of this breed, the cows were classified according to form as follows:

Milk and Beef Form
Milk Form
Beef and Milk Form
Beef Form

This form of description is no longer used. It was required for admission to the early Advanced Register by inspection. Cows are now admitted by an official test, and no description is required. The early imported cows were largely of the beef type. The present-day type demanded by the best Holstein breeders calls for a cow showing good dairy type, good wedge shape, shoulders smooth but wide and deep, the barrel long, deep, with hips and loin broad and full, udder capacious and well formed with teats squarely placed and milk veins long, large, and tortuous.

American vs. Holland Type. On the average the cattle of this breed, as found in Holland, show somewhat more of a beef type and less of a pronounced dairy type than those found in America. The Holland farmer sells his poor-producing cows for beef while they are comparatively young, and gets a considerable income from veal production. For these reasons he insists on some meat-making capacity. The Holsteins brought to America were for dairy purposes and have generally been those having the best developed milking indications, since their reputation in America is based upon their milk-producing capacity.

The opinion has been expressed by some authorities that the type of this breed in America has changed since it was first introduced. Those claiming to recognize a change attribute it to the fact that the judges at the American shows usually have a prejudice in favor of rather extreme dairy type, brought about by familiarity with other dairy breeds. This tendency was apparent for a period preceding 1915. About this time, as a result of agitation by Holstein breeders, more care came to be given by show-ring judges to recognize the true Holstein type and to avoid the judging of all breeds according to the same standard. This tendency to judge all dairy cattle by one standard, and especially the attempt to apply to the larger breeds an ideal of refinement in form based largely upon the smaller breeds, are mistakes which the agricultural college student and judges must take special care to avoid. It is probably safe to say that the typical Holstein as now bred in America is slightly smaller than the Holland animal, and a larger proportion have pronounced dairy type.

Color Marking. The color markings are variegated black and white. As a rule the breeders have preferred animals on which the two colors are about evenly divided. The colors are always sharply defined and not blended. Fortunately this breed has never been injured by a color fad, although in recent years there has been some tendency to favor those having more white than black.

Red Color in Holsteins. Among the cattle of that part of Holland from which the ancestors of the Holstein Friesian breed of America came are a small number with red and white markings in place of black and white. These animals are not discriminated against so far as registration in Holland is concerned, although the Holland breeders, especially in recent years, have preferred the black and white, and for this reason the red and white have decreased to a point of practical elimination in registered herds. It is said that less than 15 000 red and white are now registered in Holland. The unregistered herds, numbering about 80 per cent of the whole, still show up to 10 per cent of red and white. Registration in the herd book of the Holstein Friesian Association of America is open only to those having black and white markings. However, it is not uncommon for a red and white calf to be dropped that is unquestionably the offspring

of purebred black and white parents. Bulls are occasionally reported that transmit these markings to a proportion of their offspring. Such a case is no reason for raising a question of the purity of the breeding of the bull in question, as a study of genetics and inheritance fully explains this phenomenon. Such a bull should not be used in purebred herds, however.

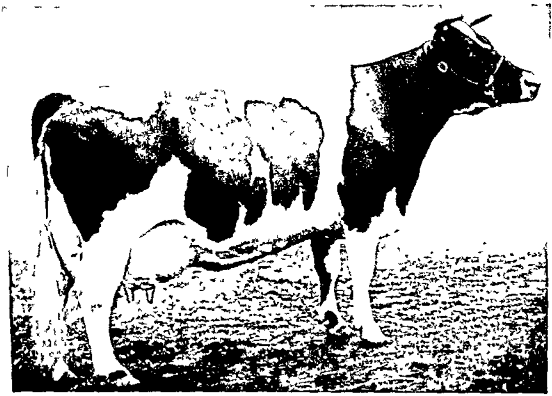

FIG. 14. Rose Hill Fayne Wayne All American Holstein-Friesian Cow 1948. Owned by F. W. Griswold. (Courtesy Holstein-Friesian Association.)

Breed Characteristics and Adaptations. As a breed, the Holsteins have the best disposition or temperament of any dairy breed. While cows of the breed as a rule have plenty of nervous energy, which is necessary for high dairy production, they are not nervous in the common meaning of that term. Where Holsteins and other more excitable breeds are kept together, the contrast is easily noticed. A change of milkers, or any sudden disturbance, such as the presence of a stranger or a dog, will produce little or no effect on most Holsteins, while cows of some other breeds will show a marked change in milk production. The Holstein is less alert and active than

the other dairy breeds but her nerves are well under control This is of considerable advantage on account of the usual necessity of having dairy cattle handled by hired men who are often more or less careless and inefficient

The Holstein cow, because of inheritance and long selection is best adapted for rather level rich pastures where liberal feeding is practicable As grazers on hilly or scanty pastures the breed is easily surpassed by the Jersey and Ayrshire—especially the latter

FIG 15 Wisconsin Admiral Burke Lad Gold Medal Sire Outstanding proved sire of both production and type (Courtesy Holstein Friesian Association)

The reproductive function of cows of this breed is good being equaled among dairy breeds only by the Brown Swiss Considerable trouble with sterility and shy breeding is experienced with all highly developed breeds but the Holstein gives as little trouble as any in this respect The calves are large weighing on the average 90 pounds at birth and they are strong and vigorous giving the minimum trouble in raising At birth the Holstein calf is the largest of all breeds except the Brown Swiss and on the average it represents 8 per cent of the weight of its mother The Jersey calf on the other extreme averages 6 5 per cent of its dam s weight

Beef Possibilities. As beef producers, the breed ranks high for a dairy breed. As in the case of the other dairy breeds, the gains in weight are made as rapidly and as cheaply as by animals of the beef breeds.[2] The market price for Holstein steers is generally lower than for animals of the beef breeds, partly as a result of color or prejudice, but mainly—as in the case with the other dairy breeds—because of the lower dressing weight, the smaller proportion of high-priced cuts, and the greater amount of offal fat.

The calves are especially well adapted for veal production on account of the large weight at birth and the rapid gains made during the first few weeks.

The Holstein does not withstand hot weather as well as some other breeds. This fact is readily observed where cows of this breed and of others are kept under the same condition in a rather hot climate. The ability of other breeds such as the Jersey to endure heat better than the Holstein undoubtedly is one reason the Jersey is the leading breed in the southern part of the United States and the Holstein in the northern part.

The breed does not mature especially early. The animals reach the maximum of growth in skeleton between the ages of four and five years, while the maximum weight is reached about two years later. Usually the heifers are sufficiently mature to come into milk at twenty-eight to thirty months. Freshening at an earlier age is not advisable, as the tendency is to check growth and to result in undersized cows.

Milk and Fat Production. No satisfactory statistics are available which show the average production of any of the dairy breeds under practical farm conditions. An abundance of data may be had which give results from official testing, but the value of such records is limited as a criterion for judging results under conditions such as exist on farms where the bulk of the milk supply of the country is produced. On the other hand, figures of production by herds on average farms, while of value, would not be satisfactory as indicating the capacity of a breed to produce milk and fat, since in too many cases the low production shown by such figures is due largely to poor feed

[2] Branaman and Brown, Michigan State College Quarterly Bulletin, 19.16-21 (1936).

and management and does not, therefore, represent the real capaci of the breed

The most valuable figures would probably be those representi entire herds on farms where a reasonable amount of culling of i ferior animals is done, where the cows are well fed, but not push by excessive grain feeding to the point of lowering the economy production, and are bred to calve at intervals of twelve months Und such conditions in a Holstein herd, an average of at least 9,0 pounds of milk and 350 pounds of fat should be expected each ye for all cows in milk, including animals of all ages

Occasionally an average of 12,000 pounds is reached under su conditions for a term of years for an entire herd, and represe exceptionally well bred animals with unusually good methods feeding and management On the other hand an average of less th 8,500 pounds should cause the owner to examine most carefully i his method of selecting, breeding, and feeding The average fat p centage for the herd will not vary much in any case from 3.53, average for the breed as shown by Herd Improvement Registry Te ing Cows testing 3 25 per cent or below are discriminated agai for breeding purposes

Characteristics of Holstein Milk The Holsteins produce m milk, on the average, and at a cheaper cost for 100 pounds, than other breed The percentage of fat averages the lowest It is clair by some breeders that the percentage of fat has been increased American breeders While it is possible that the strong efforts being made in this direction by the leading breeders have resulte richer milk from certain herds of selected animals, there is l evidence to show that the average of the breed has been chan very much, but Herd Improvement Registry Testing data are a n reliable guide Data based upon official tests are of little value in connection

It sometimes happens that the milk from a heavily producing h especially when the majority of the cows are fresh, will fall below usual legal standards in both fat content and percentage of solids fat This may be remedied, so far as the fat percentage is concer by standardization When the fat is lower than desired, a small

tion of the milk is run through a separator and the cream added to the remainder of the milk. The proportion of the total to be separated may be determined by calculation or by a formula for the purpose in common use. In case it is desirable for some high-testing herds to lower the fat content, the separated skim milk, rather than the cream, is added to the remainder of the milk.

In the past there has been a tendency to criticize the Holstein unduly on account of the well-known low fat content of the milk. If butterfat is marketed, the total quantity produced is the most important fact. It is known from practical experience that milk with an unusually high fat content is not as desirable for calf feeding as is milk with an average, or even a lower, percentage of fat. This belief on the part of practical cattlemen has been confirmed in recent years by research work both with man and animals.

The total solids of Holstein milk contain on the average 28 per cent of fat as compared with 34 per cent for the Channel Island breeds. This fact is of some importance in connection with the question of the relative economy of fat production by different breeds, as discussed in another paragraph.

Color and Size of Fat Globules. The fat globules are small, rather variable in size, and show the least yellow color of any of the breeds. On account of the small size of the fat globules, the cream does not separate so quickly nor so completely by gravity as is the case with larger fat globules. However, when a centrifugal cream separator is used, the difference in the loss of fat in the skim milk from different breeds is too small to deserve consideration. The lack of color in the fat results in the milk and cream showing much less color than if it were of equal quality, but the product of a Jersey or Guernsey. The lack of color is of some disadvantage in selling market milk or cream, since in the popular mind a yellow color is considered an index of richness.

The small fat globules are of some advantage when the milk is to be transported to market, as it makes possible the necessary handling of the milk with the minimum of churning.

Families. There are no well-defined families among the Holsteins, as is the case with some other breeds. Holstein breeders often

refer to certain animals in a way that would suggest a family—for example, speaking of a De Kol, a Johanna, or an Ormsby. Such a statement indicates that the animal in question is a descendant of the noted animal mentioned. Unlike the Jersey breed, in which the families are as a rule traced to a bull as progenitor and take their name from him, the Holstein breeders trace their lines of breeding ordinarily back to a great foundation cow. A foundation cow is one that transmits to a high degree characteristics desirable for that breed. In most cases the exceptional qualities of such animals are not recognized until their days of usefulness are long past.

The breeders of Holstein cattle have followed the practice of the Holland breeders and have had something of an aversion to inbreeding and even to line breeding. Without line breeding and more or less inbreeding it is impossible to establish a real family within a breed.

During the early development of the breed in America, certain cows rather than bulls were given prominence in Holstein breeding operations. This is still true, although not to the same extent. Descendants of cows with large official records have been in the greatest demand. However, since a large number of official records have been recorded, the value of certain bulls as sires of high-producing cows has been more fully recognized, and as a result bulls of high transmitting ability are now sought by good breeders.

Advanced Registry. The Advanced Registry has been one of the important factors in the increase of popularity of this breed in America. The Holstein-Friesian Association, and especially Mr. S. Hoxie of Yorkville, New York, should be credited with the introduction of this system—since adopted in somewhat different forms by all other dairy cattle associations in America. The plan is to make record of dairy performance, in addition to regular registration.

The first entries were made in 1886. Under the original plan, the animals were admitted on making certain milk and butter records as the result of tests made and reported by the owners themselves, and after an inspector had scored and examined the animal. This association was the first to adopt the Babcock test as their official method, which was done in 1894. At first they adopted the plan of printing the records in the form of butter, calculated on the basis of 80 per cent

fat. Later the rules were changed, and since that time the test supervisor reports the milk and fat yield. The practice, however, on the part of many Holstein breeders was to express the results in terms of butter, calculated on the 80 per cent fat basis. A 1,000-pound cow, as the term was formerly used in breed literature, meant a cow that produced only 800 pounds of fat in a year. Actual production figures in pounds of milk and fat are now used and a 1,000-pound record means 1,000 pounds of fat.

Types of Advanced Registry Tests. In the early days of Advanced Registry testing, the test period could be for only short periods such as seven days or thirty days, or for longer periods. When this test period was under the constant control or watch of the official tester, it was spoken of as an official test and the record was designated in the herd book and on pedigrees as an A.R.O. record, the abbreviation standing for Advanced Registry Official.

Such records for various reasons became less and less popular and were officially abandoned by the Holstein-Friesian Association in 1932. Today only long-time tests such as the 305-day and 365-day semiofficial and herd tests are recognized. The term "semiofficial" refers to tests which have the test supervisor present; the tester takes the weights of the milk produced and makes a fat test of each milking for a test period of 24 to 48 hours. The daily milk record for the remainder of each month is kept by the owner and is reported at the end of each month. There are minimum fat requirements for the several different age and test length classifications.

Entry of bulls. A bull is eligible for advanced registration when a certain number of his daughters have qualified for entry. The number of daughters required to qualify a bull varies with the different breeds. The Ayrshires require four daughters from different dams. The Guernseys require five. Brown Swiss, Holsteins, and Jerseys have no provision for bulls.

Herd Improvement Registry. In 1929 a new plan for keeping records was inaugurated under the name of the Herd Improvement Registry. The purpose was to obtain records on the entire herd rather than on a few outstanding individual cows. It is believed that records taken under these conditions will accelerate herd improve-

ment The record of any cow may be eliminated by the surrender of her registration certificate before the close of the test This results in much needed culling of inferior animals This test has increased in popularity in the last several years and had in 1955, 2,128 herds with 69 224 cows under test Increased emphasis is now being given through this test to continuous herd testing In addition 171 breeders had 2,657 cows on test in the Advanced Registry

Recognition and classification of herds Another innovation by the Holstein Friesian Association is the inspection and classification of entire herds, and of the daughters of sires whose transmitting ability has been demonstrated On payment of a small fee for each animal in the herd, the services of an inspector may be obtained on request by any breeder The individuals in the herd are classified into six groups EXCELLENT, VERY GOOD, GOOD PLUS GOOD, FAIR, and POOR

Table 7 Ten Highest Fat Records for Holstein Friesian Cows

COW	LBS MILK	LBS FAT
Carnation Homestead Daisy Madcap 2337079	36 414	1 511 8
Erndale Dunloggin Anna 2765454	33 198	1 494
Carnation Ormsby Butter King 1165152	38 607	1 402 0
Carnation Ormsby Madcap Fayne 1639621	41 943	1 392 4
De Kol Plus Segis Dixie 295135	33 465	1 349 3
Carnation Homestead Inka Mutual 1820797	34 681	1 333 8
Carnation Ormsby Nellie 1326284	35 887	1 328 8
Calamity Nig of Elmwood Farms 1560447	34 616	1 327 9
Knollwood Rog Apple Gay 2505100	32 888	1 327 0
Carnation Madcap Homestead Daisy 2638077	30 785	1 314 0

The owner of the herd agrees to surrender the registration certificate of all animals classed as poor" Male calves from cows in the class designated as "fair" are not eligible for registration

When sires are inspected, all daughters are taken into account and at least six in milk must be available for inspection Bulls, which in the judgment of the inspector are entitled to recognition as preferred sires, are designated Bronze Medal Preferred Sires, or when the evidence indicates outstanding transmitting ability, Silver Medal Preferred Sires

Some Advanced Registry Results. Table 7 gives the ten leading cows in fat production for 1954.

Up to 1954 there had been 40 cows with lifetime records of more than 200,000 pounds of milk. The average of these lifetime producers, was 226,572 pounds of milk and 7,694 pounds of fat.

The average of 1,973 herds totaling 50,128 cows on Herd Improvement Registry for 1953 was 11,488 pounds of milk with an average test of 3.65 per cent fat and 419.3 pounds total fat.

The Holstein-Friesian Association has its central office at Brattleboro, Vermont.

CHAPTER V

Jerseys

Origin and Distribution in Europe. The Jersey and the Guernsey breeds are often called the Channel Island breeds. They take their names from the islands of the same names, which are a part of the group called the Channel Islands. This group, which includes the Islands of Jersey, Guernsey, Alderney, and Stark, lies in the entrance to the English Channel about nine miles from the coast of France and about seventy from England.

The cattle from these islands were formerly classed together and called Alderney, after the island third in size of the group. The cattle on these islands are supposed to be descendants of the cattle of Normandy and Brittany in France. According to Keller, they belong to *Bos sondaicus* type, and are therefore related in origin to the Brown Swiss. When they were brought from France to the Islands is not known, but there has been little mixing with other cattle for a very long time. Since 1789 a law has been in force on Jersey Island which entirely prohibits the importation of cattle except for slaughter. A few years later Guernsey adopted a similar law. During World War II the Germans occupied these islands and brought some cattle from France. These were all slaughtered at the end of the occupation.

Outside of Jersey Island the Jersey breed is fairly numerous in England but only a few are used elsewhere in Europe. The first demand for them outside of their native island came from England, where they were placed on the estates of the nobility largely on account of their beauty. Even to the present time the breed has not contributed very much to the total dairy products of England.

Conditions on the Isle of Jersey. Jersey Island is eleven miles long and about nine wide. Its area is 36,680 acres, of which 25,000 are tillable. The population is about 60,000. This island rises from the level of the ocean on the south in a long gradual slope to the north side, which has cliffs about 200 feet high along the ocean. Because of the influence of the Gulf Stream, the climate is mild and even. The grass remains green throughout the year and is rather fine and nutritious. The cattle are pastured during the day by the tethering system. From May to October the cows, as a rule, remain outdoors all the time. In winter the cows are out in the daytime, and in the evening they are housed and fed hay, roots, and a small ration of bran or oil cake. But little grain is fed at any time.

Intensity of Jersey Farming. The agriculture on Jersey is very intense. At least two crops of some kind are raised each year on the same land. The average annual rental is over $50 per acre, including the ground occupied by the dwelling house and barn as well as for the cultivated land. The island was at one time in a very low state of fertility, but its productiveness has been increased until it ranks among the highest developed agricultural regions in Europe About 10,000 cows are kept on the island, or one to every 2.2 acres of cultivated land.

The cattle have been bred and improved with special reference to butter production for over a hundred years. In 1834 a scale of points was made out for both cows and bulls, and prizes were offered for the animals conforming most nearly to the scale of points. The breed began to improve more rapidly from that time on. At the present time the cattle on the island are a very uniform lot, but their average production is probably lower than that of equally good representatives of the breed in America, largely because they are fed a less liberal ration of grain, and they average smaller in size than the American Jerseys.

Registration on Jersey Island. The plan of registration of cattle on the island is quite different from that followed in America. Cows are registered as Pedigree Stock and as Foundation Stock; bulls as Pedigree Stock only. Within twenty-four hours after the birth of a heifer calf which is to be registered, the owner must notify a member

of the Agricultural Department who issues a certificate showing the calf is from the cow claimed This certificate, with one from the owner of the sire, is filed with the Secretary of Register within six months This is called preliminary registration

Every two months examinations are held for the qualification of these registered cattle The cattle to be examined are taken to the appointed place and examined by the judges If the heifers meet with the approval of the judges, they are given qualification C , if commended, or if of exceptional merit, they are given qualification H C , high commended Cows in milk which are not registered under the first qualification may be examined for foundation stock, and if passed are registered with the others When a bull comes up for examination, his dam must be shown also, and her qualifications are taken into account before registering the bull Animals passing these examinations are given herd book numbers

A system of official testing for milk and butterfat production, modeled after the Register of Merit of the American Jersey Cattle Club, was adopted several years ago, but official records have not yet attained the prominence which they hold in this country The system of registration which is followed has resulted in making the Island animals a strikingly uniform and beautiful lot

Importations and Distribution in America In 1850 several Jersey cows were imported to Hartford, Connecticut, and in 1868 S S Stephens of Montreal, Canada imported nine animals, from which have descended some of the most famous producers in the Jersey breed After 1868 importations were numerous until about 1890, then followed a period of several years when few were imported During the last decade several importations have generally been made each year The interests of the breed in the United States are looked after by the American Jersey Cattle Club Up to January 1, 1955, 2,617,701 head had been registered in the United States In 1954 there were 64,072 females and 7,044 bulls registered The ratio of registration has been about 1 to 7 for the past 12 years

Numbers and Popularity The American Jersey Cattle Club estimates that as of January 1, 1955, there were about 446,500 living registered Jerseys in the United States The Jerseys rank second in

number among the dairy breeds. The Jersey is found in all parts of America, but is most numerous in the eastern and southern states. According to the census figures the five leading states in numbers are Ohio, Texas, New York, Pennsylvania, and Missouri. The breed is making rapid progress on the Pacific Coast, especially in Oregon. The popularity of the breed has been helped by the fact that it was introduced at an early date and further by the skill shown by the American Jersey Cattle Club in looking after its interests.

At an early date this breed was afflicted by a color fad, which injured it somewhat for several years. The fad was for solid colors, which means no white markings, and for a black tongue and switch. At present little attention is paid to color, although the majority of the Jerseys found in this country have the solid colors and black points. In the late seventies and early eighties a great boom struck the breed in the United States. Cows of the St. Lambert breeding brought enormous prices. As high as $25,000 was paid for a single cow. In 1893 twenty-five animals each of the Jersey, Guernsey, and Shorthorn breeds competed in a dairy test at the World's Fair, Chicago. In both the production of cheese and butter the Jerseys won first place on total production and economy of production. This gave the breed greatly increased popularity, and their numbers increased very rapidly in the following years. They also stood first in the dairy test at the World's Fair in St. Louis, in 1904, with the highest average production and the greatest economy of production of butterfat. This recognition in the early days of dairy development in the United States helped much in making this breed popular.

Size and Type. The Jersey is the smallest of the dairy breeds, with the exception of the Kerry. The weight of the average cow is generally between 800 and 900 pounds. The bulls, as a rule, range from 1,200 to 1,700 pounds. The breeders in America have usually favored the larger animals, and for this reason, and possibly also on account of the more liberal feeding practiced, it is generally believed the breed tends gradually to increase in size after a few generations in America. Cows weighing 1,000 pounds are common here, but unknown on the Isle of Jersey. A good Jersey cow is the model of what is generally taught to be the dairy form. She has the pronounced

wedge shape, an immense barrel for her size, and a well-developed udder, and she does not carry a pound of surplus fat while in full flow of milk

Island vs American Type The difference is so marked between the imported, or their near descendants, and those descended from the early importations that the two types are genearlly recognized as the American and the Island types The American type is well represented by animals of the so-called St Lambert breeding Sophie's Tormentor, St Mawes, and Golden Glow families also have gained prominence as American bred families This type is larger and coarser than the Island type, and less beautiful, and it is often deficient in fore udder development, is inclined to coarseness in the head and pelvic region and often lacking in general symmetry Cows of the American families have so far held most of the milk and butterfat records for the breed

The Island type is smaller and more refined and beautiful in form, and splendidly developed in the udders, especially in front They have fine symmetrical heads and necks, and level, flat rumps They generally are the favorites in show ring competition, and have included the most fashionable breeding and highest-priced animals of the breed

Influence of the Early English Breeders The Jersey breed and the early practices of the Jersey breeders were influenced more by Philip Dauncey than by any other individual Dauncey began his breeding operations in 1826 and first made the breed well known in England through his remarkable breeding operations, which covered forty-one years His ideal was to develop large, rather coarse animals of great constitution and with remarkable milking qualities W G Duncan began his breeding operations in 1849, making use of the Dauncey blood, and continued the development of the same type, which is that now known in the United States as the American type

Inbreeding an Influence In developing the type, these breeders selected animals of the type they desired, and then inbred freely and continuously They also bred heifers to calve at three years of age, which was an important factor in developing a large animal The early importations to America were largely cattle from the Duncan

herd, or were descendents of the Dauncey herd. These facts show that the ancestors of many American herds were taken from Jersey Island nearly a hundred years ago and that the origin of the so-called American type of Jerseys should be mostly credited to Dauncey and Duncan It is also interesting to note the influence Dauncey's practices still have upon American breeders. He practiced inbreeding persistently, and the practice has been followed by some Jersey breeders ever since, although it has never been adopted to any extent by those interested in other dairy breeds. The fad for solid colors, which was once so strong in America, and which still persists to some degree, originated with these two English breeders.

Breed Characteristics and Adaptations. The color of the Jersey varies greatly. It may be any shade of yellow, except orange, from almost white to very dark squirrel gray or black The most common color is fawn with black shadings below and on the head. White spots may appear, most commonly on the underline, but they are not generally looked upon with favor, especially among breeders of the American type. More and more broken color is to be found in recent importations from the Island and some of the best recent show animals have been of broken color. The tongue and switch are generally black. The muzzle is intensely black, encircled by a light-colored ring. The bulls are as a rule darker in color than the cows

Nervous Temperament. Cows of this breed are very sensitive, having a highly developed nervous temperament. When carefully handled, they become exceedingly gentle. On the other hand, when carelessly handled or abused, they become very much the reverse. They are more easily disturbed by unusual surroundings than other dairy breeds.

Jerseys are easy keepers; but like all dairy animals, they need good pastures and liberal feeding for good returns. They do better than the Holsteins on rough and scanty pastures, but they are not equal to the Ayrshire in this respect. They seem to thrive in warm southern climates better than some other breeds.

Beef Possibilities. As meat producers they stand low, even for dairy breeds. The body fat is very yellow and is not well distributed. The calves are small, weighing between 50 and 60 pounds at birth,

and do not gain rapidly for the first few weeks. For this reason they are not well adapted for veal production. If Jersey calves are raised for meat, they should usually be sold by the time they are eight or ten months old.

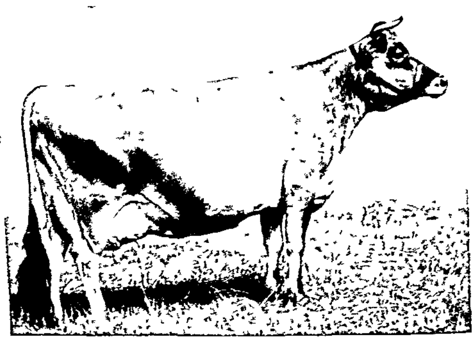

FIG. 16 Jersey cow, Imp Wonderful Snowdrop No 941016 Reserve Grand Champion Jersey cow National Dairy Show, 1937 Record 5 years 4 months, 545 36 pounds butterfat, 10 135 pounds milk—305 days—Class AAA. She represents an excellent combination of breed and dairy type and production. (Courtesy American Jersey Cattle Club)

The breed is very prepotent when crossed upon common cattle or grades of other breeds The cross usually partakes strongly of the Jersey type and milking qualities The heifers mature young. They are usually sufficiently well developed to come into milk at the age of twenty-four to twenty-six months The lack of vigor in the calves at birth and the mediocre breeding qualities of the cows are generally considered the weakest points of the breed

Dairy Characteristics. Under good farm conditions an average yearly production of 6,500 pounds of milk and 350 pounds of fat, including all females of milking age, would be considered satisfactory.

Under Jersey herd test rules all Jersey cows and heifers had completed 171,365 records in the past 10 years with an average production of 7,120 pounds of milk and 379 pounds of butterfat with a test of 5.32 per cent. This should be considered a representative production for the breed. An average of 8,000 pounds of milk, or more, should be aimed for and can be obtained under the best conditions.

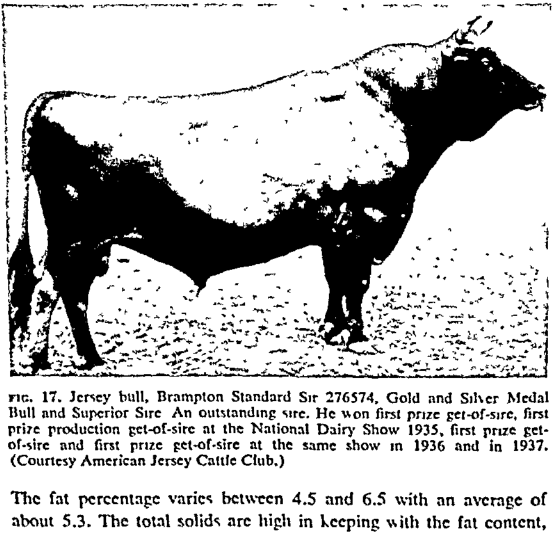

FIG. 17. Jersey bull, Brampton Standard Sir 276574, Gold and Silver Medal Bull and Superior Sire An outstanding sire. He won first prize get-of-sire, first prize production get-of-sire at the National Dairy Show 1935, first prize get-of-sire and first prize get-of-sire at the same show in 1936 and in 1937. (Courtesy American Jersey Cattle Club.)

The fat percentage varies between 4.5 and 6.5 with an average of about 5.3. The total solids are high in keeping with the fat content, averaging 14.9 per cent. The fat, on the average, constitutes 34.5 per cent of the total solids as compared to 28 per cent for the Holsteins.

In quantity of milk the Jersey breed is excelled by several others, but in fat yield it ranks equal to any. On account of its richness Jersey milk cannot be produced and sold in competition with that

from other breeds where weight or quantity is the basis of payment In some fluid milk markets, a special price is paid for Jersey milk to be marketed as Jersey Creamline milk Where milk is purchased for market purposes or for condenseries it is often the practice to pay a price per hundred for milk with a minimum fat content, usually 3 5 per cent, with a small increase for each tenth of a per cent or "point" above 3 5 The price paid for the fat above the minimum is less than that for the basal amount and this discriminates against the cow giving the high testing milk For these reasons the Jerseys are not as popular as some other breeds in whole-milk marketing localities

Economy of Fat Production As an economical producer of butterfat, the Jersey and her near relative, the Guernsey, are unsurpassed The Jersey milk has the highest per cent of fat of any dairy breed common in this country In economy of production of fat this breed has always led, where opportunity has been given to make fair comparison with other breeds The economy of fat production is to be attributed to two factors One is the fact that the fat represents a greater proportion of the solids than in other breeds, in other words, less skim milk is produced to the pound of fat The second is the smaller proportion of the ration used for maintenance A Jersey weighing 900 pounds will produce as much fat on the average as a Holstein weighing 1,250 pounds In this case the cost of maintaining the larger cow adds to the feed cost of the fat produced

Butterfat Characteristics The most prominent and best-known characteristics of Jersey milk are the high per cent of fat, the pronounced yellow color, and the easy creaming of the milk The latter characteristic is due to the unusually large fat globules The large fat globules also cause the fat to churn easily, which is something of an advantage in butter making The same ease of churning is a slight disadvantage when the milk is to be handled much, as in the market milk business, because it results in small masses of butter appearing on the surface

The Jersey a Family Cow. In persistency of milking the Jersey ranks very high, probably the highest of any breed Cows of this breed

are general favorites as family cows on account of the richness of their milk, its easy creaming characteristics, their persistency of milking, their easy keeping qualities and gentleness.

Register of Merit. In 1884 the Jersey Cattle Club authorized seven-day butter tests. The first volume of these tests was published in 1889. These tests covered seven days' time and were made by the owner, who afterwards took oath to the correctness of the results reported. Cows producing 14 pounds or more of butter in seven days were admitted to this registry, and such cows were afterwards spoken of as tested cows, or were said to be in the "14-pound list." These early private butter records did much to popularize the breed but soon fell under suspicion because of the excessive records reported. They are no longer used or recognized.

In 1903 the Register of Merit was established and the rules were changed to admit records made by using the Babcock test.

In 1911 the rules were amended so that only authenticated butterfat and milk records were accepted covering seven days or a full year, and in 1919 the seven-day test was dropped and provision made for other classes. At present cows are entered in the Register of Merit in three classes: class AAA, class AA, and class A, the classification depending on age and calving requirements.

Testing for the Register of Merit is conducted under the usual condition of Advanced Registry of the other breeds. The owner weighs and records the milk at each milking during the year. For two days each month, or bimonthly as the owner may elect, a representative of the Superintendent of Official Testing for the state weighs the milk and determines the fat percentage. The Register of Merit has made rapid strides in recent years and many very creditable records have been reported. At the close of 1954, some 224 breeders had 2,286 cows on Register of Merit test and 1,034 herds with a total of 32,404 cows were on Herd Improvement Registry tests.

The Herd Improvement Registry was established in 1928 as a branch of the Register of Merit. The special purpose is to obtain a record on the entire herd. All registered cows in the herd must be included in the testing, and the period covered in the published

report is a calendar year Records made in Herd Improvement Associations are accepted if certified by the official in charge of Register of Merit testing in the state where the herd is located The results are safeguarded by frequent retests of all cows showing a high level of production. This type of testing has become very popular not only with Jersey breeders but with all other breeds as well The American Jersey Cattle Club for many years had its central office in New York City, but in 1947 moved to 1521 East Broad Street, Columbus, Ohio

Herd Classification In 1932 the American Jersey Cattle Club adopted a herd-classification plan for type by which, on application, any breeder may have his entire herd officially classified by an official inspector or judge designated by the Jersey Cattle Club The animals so classified are rated in six classes 1 EXCELLENT, 2 VERY GOOD, 3 GOOD PLUS, 4 GOOD, 5 FAIR, 6 POOR.

Table 8 Ten Highest Butterfat Producers for the Jersey Breed, 1954

COWS	LBS MILK	LBS FAT
June Volunteer Fantasy	20,097	1,319
Opal Crystal Lady	23,725	1,237
Orrland Signal Vol Sable	19,497	1,223
Stockwell s April Pogis of H P	17,880	1,218
Blossom Susie of Redmond	21,243	1,210
Abigail of Hillside	23,677	1,198
Volunteer Winsome Victory	18,367	1,174
June Volunteer Pietzi B	19,126	1,151
Welcome Volunteer Sable	18,998	1,144
Darling s Jolly Lassie	16,475	1,141

Prominent Jersey Families There are some fairly well marked families in this breed The first to gain prominence was the St Lambert This family originated in Canada, and is descended from the cattle imported by Stephen of Montreal and St Clair of Vermont The bulls Stoke Pogis and Stoke Pogis 3d are supposed to be predominant factors in the formation of this family, which included many of the best-known animals of this breed in America Animals of this early family, as a rule, are large in size and often rather coarse in make-up generally fawn or gray in color, and seldom black It has

produced many remarkable dairy cows. Like other prominent Jersey families, it is deeply inbred.

Other families which have gained distinction are the Golden Glows, Eminents, Raleighs, St. Mawes, Owl-interests, Majestys, and Sophie's Tormentors. Each of these families has descended from a great foundation bull whose blood has been concentrated by close line breeding or inbreeding.

CHAPTER VI

Guernseys

Origin and Distribution in Europe. The Guernsey breed originated on the island of the same name Like the Jerseys, they are presumably descended from the cattle of France, but their true origin has not been distinctly determined Each account indicates that in the year 960 an order of monks settled on the Island of Guernsey and brought with them small native cattle from Brittany. About 1061 another monastery was established, and the monks in this monastery introduced the larger brindle cattle of Normandy. The crossing of these two stocks is believed to have laid the foundation for the present Guernsey breed A century ago the cattle on the islands of Jersey and Guernsey were practically the same in form and color, but even then the Guernsey is said to have been a little larger In 1824 laws were passed prohibiting the importation of cattle into Guernsey, and since that time there has been but little mixing with other breeds During World War II the island of Guernsey was under German occupation with some cattle being brought in from France which were later slaughtered, new herds of Guernseys were also established on Alderney following the occupation

Professor Low,[1] writing in 1845, says that the cattle of Guernsey and Jersey were at that time essentially the same, although he further describes the former as being larger, the form rounder, and the bones less prominent than with the cattle on Jersey Island He also refers to the unusually orange yellow skin and yellow milk and butter It

[1] *Domesticated Animals of the British Islands* p 339 Longman, Brown Green and Longmans, London (1845)

appears, *from* his writings that these two breeds at that date were nearer together in type, but that the Guernsey showed the same characteristics in general as at present. There appears to be fairly substantial evidence of an occasional mixing with other breeds in the early development. The present marked difference between the two breeds is doubtless due largely to the developments of the past century.

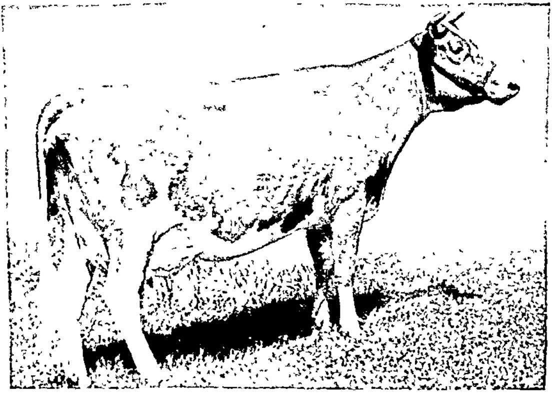

FIG. 18. Quail Roost Noble Primrose. Senior and Grand Champion and best-uddered cow, Dairy Cattle Congress 1946 and National Guernsey Show 1947. Jr. four-year record 15,730 pounds milk, 744 pounds butterfat. Owned by Curtiss Candy Company. (Courtesy American Guernsey Cattle Club.)

The Guernseys have been taken to England in appreciable numbers, and are used considerably, especially in the southwestern part, but on the whole they are of little importance in that country from a dairy standpoint on account of their comparatively small numbers. They are not found elsewhere in Europe to any extent.

Conditions in Guernsey. The conditions on Guernsey Island are practically the same as in Jersey. The island is second in size of the

Channel group, and has a population of about 45,000 It is ten miles long, with an area of about 16,000 acres—of which 12,000 are tillable The climate is a little more severe than that of Jersey, as it is exposed toward the northwest The south coast rises from 200 to 400 feet above the ocean, and slopes to the level of the ocean on the north

The system of agriculture and the general management of the cattle is much the same as that followed in Jersey As in Jersey, the farms are very small and the agriculture very intensive Much vegetable production is carried on under glass There are about 8,000 cattle on the island, and they are mostly in small herds of three to six cows Green feed is available throughout the year In addition, the cattle are fed largely on hay and roots, but the practice of feeding grain in addition is being more generally adopted and is resulting in improved condition of the cattle The Guernsey breeders have kept in view the idea of utility alone, and have given less attention to the development of the beauty of their breed In 1830 a scale of points was adopted to establish uniformity in the breed This has been continued with occasional modifications to the present time

In 1879 the first Guernsey Herd Book was published which was later accepted by the Royal Guernsey Agricultural Society In 1881 a rival publication known as the *General Herd Book of the Island of Guernsey* was set up, but apparently the latter was unsatisfactory, and in 1902 the American Guernsey Cattle Club ceased to recognize it.

A system of advanced registry testing similar to that of the American Guernsey Cattle Club was adopted in 1911 by the Royal Guernsey Agricultural and Horticultural Society

Importation to America According to C L Hill,[2] the chronicler of the breed, the first Guernsey cattle introduced into this country on which acceptable records were kept were an importation by a Mr Prince, of Boston Massachusetts, about 1830 Descendants of these cattle have been recorded by the American Guernsey Cattle Club The same writer records another importation in 1840 by Nicholas Biddle of Pennsylvania Small numbers were brought in at

[2] *The Guernsey Breed* p 104 Fred L Kimball Co Waterloo Iowa (1917)

infrequent intervals, but it was not until about 1880 that they began to arrive in appreciable numbers. About that time S. C. Kent, of Pennsylvania, became one of the most active importers. There was a lull in the movement from 1895 until 1901, when importations were renewed and have continued up to the present time.

The American Guernsey Cattle Club was founded in 1877. Up to January 1, 1955, a total of 2,131,484, animals had been registered in the Guernsey Register, the first volume of which was issued in 1878. It is estimated that there were 700,000 living Registered Guernseys in 1954. There were 81,345 registered in 1954.

Guernseys are most popular in the East and North Central sections of the United States. They are especially popular in New York, Massachusetts, Pennsylvania, Wisconsin, and Minnesota Ohio, Indiana, and Michigan are rapidly becoming important Guernsey states. Their rapid increase in popularity within recent years has been brought about to no small extent by the excellent system of yearly records established by the Guernsey Cattle Club and by the excellent records made.

Form and Characteristics. The Guernsey cow weighs about 1,000 pounds on the average, ranking in size about the same as the Ayrshires, and at least 100 pounds larger than the Jersey. This breed is coarser boned and more irregular in conformation than the Jersey. The common colors are a reddish yellow, or lemon or orange fawn, with white markings. The white markings are usually found on the face, flanks, legs, and switch, but may be on any part of the body. A cream-colored nose is desired and some breeders are prejudiced against black muzzles.

Dairy Temperament. The temperament of the Guernsey cow is good. She is alert and wide-awake, but not nervous and irritable. She has a good dairy conformation, and gives the impression of a plain animal bred for utility. While the breed still lacks uniformity in type to some extent, there has been a marked improvement in this respect in recent years. As a breed they do not mature quite as early as do the Jerseys. The heifers should come into milk at the age of twenty-six to twenty-eight months. Like the Jerseys, this breed has little adaptation for meat production.

Dairy Characteristics In the yield of milk and fat percentage the Jersey and the Guernsey are not far apart the Jersey leading slightly in richness of milk and the Guernsey in total milk production A summary of all Advanced Registry records up to 1952, totaling 171,282, showed an average of 9,816 pounds of milk testing 4 8 per cent fat and 484 pounds butterfat Under Herd Im-

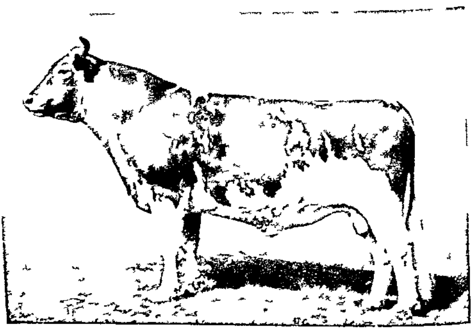

FIG. 19 Ideal s Superior Bred and owned by Jacob Tanis of Augusta, New Jersey this great bull has ten AR daughters all of which have produced over 700 pounds of fat. The ten records average 15 651 pounds of milk and 838 pounds of fat Sire Gardenville Supreme Dam Ideal s Noranda s Susie (Courtesy American Guernsey Cattle Club)

provement Registry up to 1952, 97,312 records averaging 8 175 pounds of milk testing 4 8 per cent of fat and 397 pounds fat had been made

The fat in Guernsey milk constitutes about 35 per cent of the solids as compared with 34.5 per cent for the Jerseys and 28 per cent for the Holsteins Guernsey milk is very popular for select or premium market milk and this breed is gaining in popularity in large market milk areas

Butterfat Characteristics. The fat content will be 4.8 per cent or a trifle less on the average. In color, Guernsey milk ranks first, and for this reason it is often mixed with that of other breeds for the sake of the high color it imparts. Guernsey cream, because of its color, is in demand for table use, and it often commands a premium on the market on this account.

The color of Guernsey butter is high, especially when the cows are on fresh pasture. The fat globules are on the average the largest of all breeds. The Guernseys have the same advantages and disadvantages as the Jerseys as producers of market milk. On the whole, it can hardly be claimed that the breed is especially adapted for this purpose since it is seldom possible to sell market milk on such a basis as to do justice to the very high-testing product. However, in economy of production of butterfat, this breed ranks high on account of the richness of the milk and the large production in proportion to the size of the animal. For this reason the Guernsey breed is most often used where cream is sold either for butter purposes or for table use.

Guernsey Families. The concentration of blood of certain individuals resulting in the formation of well-defined families is not so extensively practiced by Guernsey breeders; but the distinction gained by the descendants of some animals had led to a demand for offspring of similar breeding. Perhaps the most prominent group is the early May Rose family, descended from the cow of that name. Numbered among her descendants are Imp. King of the May, Ne Plus Ultra, and other animals, both male and female, that have won fame. Imp. Glenwood Girl, through her twelve calves, left a long list of productive descendants. The bulls Governor of the Chene, Sheet Anchor, and Masher may also be listed as founders of families of renown. Governor of the Chene has the distinction of being the first bull of any breed to have one hundred daughters with yearly records. The Levity, Steadfast, Maxim, and Musical families are popular at this time.

Advanced Registry Results. No breed has profited more by advanced registry testing. An excellent system of testing for this purpose was adopted by the Guernsey Cattle Club in 1901. The test period at first was for either seven days or a year; but the short-test period was

soon discarded and now all tests cover a year The testing is supervised in the usual manner by the agricultural college or experiment station The test supervisor weighs and tests the milk of each cow for either one or two days as preferred by the owner

At present, cows are entered in the Advanced Register in three classes, known as the *single letter class*, *the double letter class*, and the triple letter class The differences in these classifications depend upon age, length of test period, and calving requirements On January 1, 1955, there were 489 herds with 9,403 cows on Advanced Register test

A Herd Improvement Division was established at the beginning of 1930, the purpose of which is to keep records made in Herd Improvement Associations when supervised and certified by officials in charge of Advanced Registry Testing The same age classes are made and designated by letters as in the other classes, with the addition of the letters HI On January 1, 1955 there were 1,009 herds including 29,005 cows on regular Herd Improvement Test in the Herd Improvement Division

Table 9 Ten Highest Butterfat Producers for Guernsey Breed

COWS	LBS MILK	LBS FAT
Western Glow Butterfat Miss	21 573	1 095
Fer Manor Martha	17 230	1 020
Vermillion Pride's Carolyn	17 751	979
Matapa Consul's Senorita	17 589	973
Favorite's Dora Daisy	17 491	934
Mary of Betts Homestead	15 291	926
Fairlawn Calandar	17 458	925
Four R Alpha	14 873	915
Pleasant Lawn's Blossom	15 514	914
Hilltop Bonny Ultra	18 509	911

A bull is admitted to advanced registration automatically after two of his daughters have been entered The appreciation of the value of advanced registry testing is attested by the fact that more than 30 000 records have been accepted by the Guernsey Cattle Club

The central office of the American Guernsey Cattle Club is at Peterboro New Hampshire

CHAPTER VII

Ayrshires

Origin and Distribution in Europe. The native home of this breed is the county or shire of Ayr in southwest Scotland. It is comparatively a new breed, but has made wonderful advancement in a short time. When surveys of the country were being made around 1600, the surveyor commented on production of large amounts of butter per acre in the district. Following the period of religious persecution, Barbara Gilmour returned from refuge in Ireland, and introduced the making of Dunlop cheese on a local farm before 1700. Outlets for butter and cheese helped to create an interest in milking cows by providing sources of income. The native stock were reported to be predominately black and white. The local cows were described in 1750 as being small, ill-fed, and ill-shaped. Undoubtedly, they descended from the earlier small cattle in the British Isles, *Bos longifrons*, prior to the Roman occupation, modified by later crosses from northern Europe during the Norse, Saxon, and other settlements in coastal districts.

Influence of Other Breeds. During the latter half of the eighteenth century a widespread movement for better cattle extended over Great Britain, and resulted in an immense improvement being made in the cattle of Ayrshire as elsewhere. The improvement was brought about by more careful selection and breeding following the enclosure of lands, introduction of new crops, and especially by the introduction of blood from several other regions. So-called "Dutch" cattle of brown and white color, descended from animals brought to the Durham and Teeswater districts in northeastern England, were introduced

by several persons and exerted a considerable influence Some Channel Island blood also was brought in and used to some extent It is also probable that some Holderness blood was introduced at an early date A later infusion of West Highland blood in the herd of a prominent breeder changed the horn character and possible thickness of form, as this herd was a source of breeding bulls for other leading herds

As the improved cattle spread from Dunlop parish over the district of Cunningham and then more widely, they were called successively the Dunlop, Cunningham, and later the Ayrshire breed

Organization of agricultural societies led to further improvements by conducting cattle shows During the early part of the nineteenth century the hindquarters were improved and the udder was brought to its present symmetrical proportions Starting in 1903 the Highland and Agricultural Society of Scotland initiated a system of milk recording among dairy herds

The Ayrshires are the leading dairy cattle in Scotland, and are common in parts of England They are one of the few British breeds that has spread to the Continent, where they are fairly numerous in Finland, Sweden, and Norway In New Zealand and Canada they are one of the important dairy breeds

Conditions in Ayrshire Ayrshire is situated on the southwest coast of Scotland The land rises from the level of the ocean on the west to mountains about 2,000 feet high on the east The soil is a heavy clay of moderate fertility spread over a hilly surface The temperature ranges from 25° to 65° F during the year and is not subject to great extremes, although occasionally swept by fierce storms The moist air and abundant rainfall result in good pastures The milk is used mostly for cheese-making The herds in Scotland are usually fairly large and well handled, the breeding stock is found largely in the hands of a small number of noted breeders

Importation and Distribution in America. The Ayrshires were brought to Canada by Scotch settlers in the early part of the nineteenth century More recently the importation of breeding stock into Canada has been extensive The first importation into the United States was probably in 1837, when several were brought to Massa-

chusetts by the Society for the Promotion of Agriculture, although it is claimed that some were taken to Connecticut as early as 1822. These importations continued at intervals for twenty to thirty years, then gradually ceased, largely on account of serious objection raised to the short teats of the imported animals.

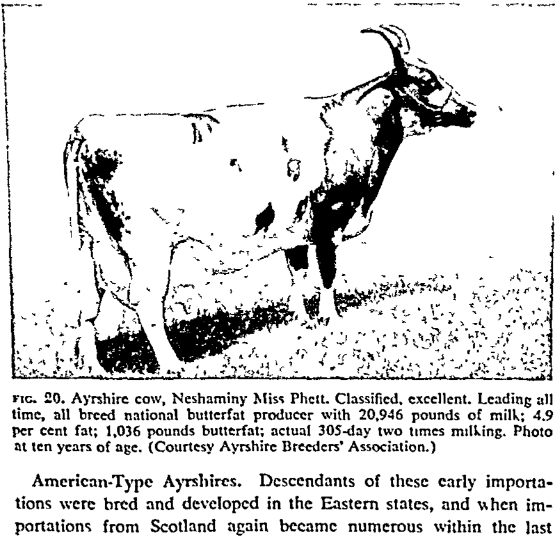

FIG. 20. Ayrshire cow, Neshaminy Miss Phett. Classified, excellent. Leading all time, all breed national butterfat producer with 20,946 pounds of milk; 4.9 per cent fat; 1,036 pounds butterfat; actual 305-day two times milking. Photo at ten years of age. (Courtesy Ayrshire Breeders' Association.)

American-Type Ayrshires. Descendants of these early importations were bred and developed in the Eastern states, and when importations from Scotland again became numerous within the last twenty years, it was found that the New England Ayrshires were considerably different animals from the breed as it has been developed in Scotland. The type as deveolped in the Eastern states came to be known as the American type in contrast to the imported animals known as the Scotch type. In recent years the importation of Ayrshires both to Canada and the United States have been numerous, and the imported type has practically superseded the early New England type.

The Ayrshire breed has never been as popular or as well advertised in the United States as the other major dairy breeds Their increase in popularity has been due, therefore, entirely to their merits The first herd book of the breed was established in the United States in 1863, *publication of the Scotch* Herdbook began in 1878, and of the Canadian in 1870

Up to 1955 there had been a total of 625,406 animals registered, with 22,993 registered in 1954 The leading states in order of numbers are New York, Pennsylvania, Massachusetts, Vermont, and Ohio The breed is also common in sections of eastern Canada, where in some localities it is the predominating breed It is estimated that there are about 150,000 living registered Ayrshire cattle in the United States

Breed Characteristics In size the Ayrshires rank between the Guernsey and Holstein breeds The average cow weighs about 1,000 pounds at maturity, while some exceed this figure considerably The bulls range from 1,400 to 2,000 pounds The tendency in America has been to favor a rather larger type than that considered most desirable in Scotland.

The common color is spotted red or brown and white, in varying proportions In the old American type the red or brownish red usually predominated, with only a small amount of white, while in the modern or Scotch type the white generally predominates The two colors are distinct, and do not blend to form a roan The horns are rather long and as a rule curve outwards and upwards and in some cases slightly backwards The bulls have very *heavy horns*

Dairy Temperament In disposition they stand somewhere between the Jersey and Holstein They are more active and alert than the Holsteins and, like them, are less affected by unusual surroundings than are some other breeds In form the Ayrshires do not show the extreme angular dairy type exhibited by high-class Jerseys or Holsteins They are smoother over the shoulders, back, and hips, and have fuller rear quarters At the same time, the barrel is large showing great capacity, and the udder development the most perfect of any breed For many years the Scotch breeders have bred especially for large, symmetrical udders, and have attained this end

with remarkable success The udder is attached high behind, and extends far forward, with a flat even, lower surface The teats are placed regularly on the udder, and are of uniform size Ayrshires are regular and sure breeders, the probable result of the favorable conditions under which the breed has been developed, and of the avoidance of inbreeding

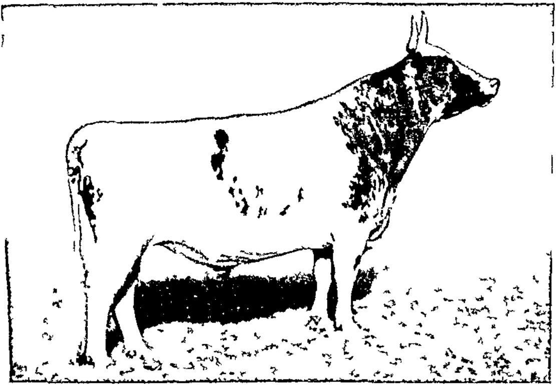

FIG 21 Ayrshire bull Neshaminy Preferred This bull is a top production transmitting sire a maternal grandson of Penshurst Man O War His 42 unselected daughters have 81 records averaging 12,248 pounds of milk 4 34 per cent fat 532 pounds fat M E 2x (Courtesy Ayrshire Breeders Association)

The chief criticism of the imported Ayrshires and their descendants is the short teats, which are often altogether too small for convenience in milking This objection, which seems to be given more weight in America than in their native home, is receiving the attention of American breeders and will soon be a thing of the past

Cows of this breed also show a tendency in many cases to lack persistency in milking This is especially noticeable with the short-bodied blocky type of cows common in herds of Scotch breeding

The Ayrshire is not so early maturing as the Jersey, ranking about

with the Holstein in this respect At twenty-four months of age the Ayrshire cow, on the average, has attained 94 per cent of her mature height, while the Jersey has reached 97 per cent at this age The Ayrshire reaches full weight at the age of approximately six years Cows of this breed are sufficiently mature to come into milk between 26 and 30 months of age It is claimed that representatives of this breed retain their breeding powers and remain profitable producers to a greater age than is common with other breeds

Grazing Efficiency. One of the strong points of Ayrshires is their excellent grazing qualities They will thrive and keep in excellent condition on pastures where animals of the larger breeds, especially the Holsteins, will find it difficult to maintain themselves The author has observed this in a striking manner when pasturing a group consisting of purebred Holstein, Jersey, Shorthorn, and Ayrshire heifers in the same pasture during a season of poor pasturage The Ayrshires made excellent gains and kept in good flesh, while it was necessary to feed considerable grain to the Holsteins to keep them in even a fair condition of flesh The others were given no grain, and remained in fair condition—but uniformly below the Ayrshires

Calves of the Ayrshire breed weigh 60 to 75 pounds at birth and are usually strong and vigorous, although not equal to the Holsteins in this respect The breed ranks high in beef production for a dairy breed When dry, the cows fatten readily and are said to furnish a good grade of beef

Dairy Characteristics As a breed, the Ayrshires are noted for a good, uniform production of milk While some very large milk and fat records have been made in official tests, Ayrshires have not so far equaled the Holsteins Guernseys, and Jerseys in this respect

Under good farm conditions with reasonable attention to culling out the inferior animals, the average production should be from 6,500 to 7,000 pounds of milk containing approximately 4 per cent of fat A production of 8 000 to 9,000 pounds of milk for the year would be considered excellent and would indicate a combination of well bred animals and expert care A production less than 6 000 a year calls for careful examination as to the methods of selection, breeding, and feeding practiced

Butterfat Characteristics. The fat globules are small and the milk and butter do not show much yellow color, ranking in this characteristic with the Holsteins. The Ayrshire cow is well adapted for the production of market milk on account of the large yield of milk of average composition. The lack of a more pronounced yellow color is some disadvantage in this connection, while the small fat globules resulting in less trouble from churning in transit is something of an advantage.

The milk of this breed is also well adapted for cheese-making on account of the small fat globules and relatively high percentage of casein, and is generally used for this purpose in their native land.

In economy of fat production the Jersey and the Guernsey breed slightly excel the Ayrshire, for reasons explained elsewhere. In regard to milk production the reverse is generally true.

Advanced Registration. A system of Advanced Registration based upon official tests was established by the breed association in 1902. Two divisions were used until 1927. The 365-day division had a minimum requirement of 6,000 pounds of milk and 250.5 pounds of fat at the age of two years, increasing with maturity to 10,000 pounds of milk and 400 pounds of fat. This division was discontinued in 1927.

In the second division, called the Roll of Honor, cows are entered that meet certain production requirements in 305 days and give birth to a calf within a specified time. Since 1927 this division has greatly increased in importance.

The testing is conducted in the usual manner under the supervision of the agricultural college or experiment station in the state where the particular herd is located. The minimum requirements for entry are 6,400 pounds of milk and 256 pounds of fat by a cow calving at two years of age, with an increase with age until 400 pounds is reached for the five-year-old animal. An important part of the requirements for admission is the birth of a living calf within 400 days from the date of beginning the test.

The Ayrshire breed took the lead in establishing in 1925 what is called the Herd Test. In 1955 there were 15,963 cows on test. The object of this type of testing is to bring about more rapid improve-

ment by having all members of the herd under test rather than a few of the outstanding animals, as was the tendency under the older plan of conducting Advanced Registry records. At the end of the year, certificates are issued for each herd, giving the production of the individual cows and the herd. In 1953, 13,599 Herd Test records averaged 9,349 pounds of milk, 4.1 fat test, and 382 pounds fat. *The Ayrshire breed in 1954 had 773 cows which had lifetime records* of 100,000 pounds or more of milk. This is an excellent example of the longevity and hardiness of this breed.

Table 10 Ten Highest Herd Test Records for Ayrshire Breed

COWS	LBS MILK	LBS FAT
Neshaminy Miss Phett	20 946	1 036
Pars Red Shelia	20 984	937
Laneway Spotties Mistress	19 686	930
Strathglass Brown Peg	18 787	874
Vista Grande Mildred	17 732	868
Lippitt August Lassie	19 440	861
Neshaminy Katie	18 833	858
Tee Pee Lassie	19 353	835
Meredith Lady Lent	19 333	834
Alta Crest Jonquil	19 660	832

The central office of the Ayrshire Breeders' Association is at Brandon, Vermont.

Slow Maturity. The Brown Swiss breed is not a very early maturing one—ranking about with the Holstein breed, or perhaps a little behind in this respect In Switzerland the cows usually come into milk at about three years of age While they are rather slow to mature, they are noted for continuing to be sure breeders until they reach an advanced age Their excellent breeding characteristics, one of the strong features of this breed, come from the favorable conditions and the sensible management under which they have been kept.

In its native home the Brown Swiss is considered a triple-purpose breed, and it was formerly classed as dual-purpose in the United States However, in 1906 the Brown Swiss breeders in America decided that their stock should be classed as a dairy breed, and indicated their intention to develop it with this purpose in view

The animals produce a fair quality of beef, grow rapidly, and reach a good size at an early age, but they are not received very well on the market on account of the large bones, and probably, in part, from prejudice on account of their similarity in color to the Jerseys For production of veal they rank high, as the calves are large at birth and grow rapidly

Dairy Characteristics. The records of the milk and butterfat production available for this breed indicate a very satisfactory average yield The United States Consul at Zurich reported some years ago that 6,000 cows supplying the Anglo-Swiss Condensed Milk Company averaged 5,115 pounds of milk yearly with an average fat content of 3 68 per cent A herd of fifty cows owned by the Agricultural School at Plantahof for five years averaged 5,990 pounds of milk for each cow in milk The highest fat yield was 513 pounds, while 23 were above 400 pounds It should be kept in mind that these figures represent the production of cows receiving little if any grain in accordance with the common feeding practice of Europe One of the leading herds in the United States at one time included 33 animals with an average record of 9,000 pounds of milk in a year. Nine of these had exceeded 11,000 pounds Under good farm conditions with reasonable care in culling the inferior animals, a herd of Brown Swiss should be expected to average from 8,000 to 9,000 pounds of milk yearly with a fat content of about 4 per cent. The

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average percentage of dry matter is 12 5 In composition the milk of this breed is well adapted for market milk purposes containing about the proper amount of fat and solids In natural color the milk is about the same as that of the Shorthorn breed

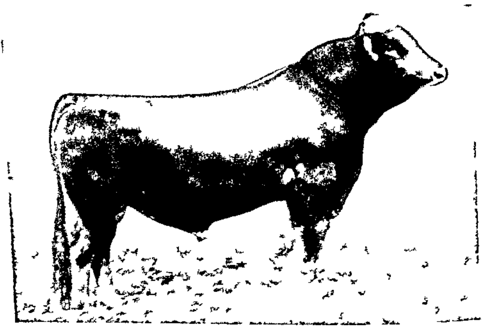

FIG 23 Brown Sw ss bull Jane s Royal of Vernon Classified Excellent. S re of breed s highest producing cows Excellent transmitting sire (Courtesy Brown Swiss Cattle Breeders Association of America)

Advanced Registration In Switzerland the interests of the breed are looked after very carefully by a co-operative association which is partially subsidized by the government The animals used for breeding purposes are approved by representatives of this association which also holds fairs at intervals which serve as means for marketing sur plus animals The breeding herds are well controlled by this association and their interests promoted so skillfully that the surplus stock is readily disposed of at good prices to meet the demand of other parts of Europe Authenticated records of milk production are kept of the best cows and the bulls from those cows are offered for sale for breeding purposes

A system of advanced registry known as the Register of Production

was established by the Brown Swiss Cattle Breeders' Association in 1911. Two types of tests are provided for: the year's test covering 365 days, with no calving requirements, and the 10-months or 305-days test which requires a calf born within fourteen months from the freshening preceding the test period. The tests are supervised in the usual manner by the agricultural college or experiment station and cover two days each month. The requirements for admission to the Register of Production are now based upon butterfat production alone, the milk production requirements formerly in use having been abandoned.

The highest record up to 1955 was held by Royal's Rapture of Lee's Hill, No 115541. At ten years she made a 35-day record of 34,669 lbs. of milk, 4.23 per cent fat, and 1,465 3 lbs of fat.

Table 11. Ten Highest Yearly Brown Swiss Milk and Butterfat Records, 1948

COWS	LBS MILK	LBS FAT
Royal's Rapture of Lee's Hill	34,669	1,465 3
Royal's Gina of Lee's Hill	28,439	1,359 7
Gypsie Jane of Lee's Hill	30,673	1,358 1
Lady's Gypsy Girl F	29,049	1,302 5
Royal's Aster of Lee's Hill	29,431	1,241 1
Royal's Shadow of Lee's Hill	28,284	1,232 7
Clepe's Best M B	25,436	1,207 5
Royal's Surprise of Lee's Hill	24,596	1,205 1
Illini Nellie	29,569	1,200 6
Junior Lady R. J B	28,663	1,194 5

In 1954 there were 61 breeders with 548 cows on R O P. test, and 368 breeders with 8,836 cows on Herd test

The central office of the Brown Swiss Cattle Breeders' Association is at Beloit, Wisconsin.

CHAPTER IX

Minor Breeds

DUTCH BELTED

Origin This oddly colored breed originated in north Holland and has been bred for over 200 years to produce a perfect belt of pure white in the center of a coal black body Very little is known of its history, it is probably descended from the same cattle of Holland, the ancestors of the breed known in America as Holstein

The Dutch Belted breed first attracted attention about 1750, but the selection and breeding for the white belt probably began long before this, possibly as far back as the sixteenth centruy According to the early records, these cattle were bred by the nobility of north Holland on account of their peculiar markings Hogs and poultry were also bred with a somewhat similar white body line The development of these animals with this distinct belt of white between coal black ends of the body is a striking illustration of the possibilities of breeding and selection

In size, the Dutch Belted cattle rank about equally with the Ayrshires Their general form and conformation are more like those of the Holstein however The cows weigh from 900 to 1,300 pounds the bulls from 1,600 to 2 000 pounds The dairy type is highly developed, being of a highly nervous temperament but a very quiet disposition Their most distinctive characteristic is the presence of the white belt around the center of the body This belt should extend around the body from just behind the shoulders to just in front of the hips Otherwise the body is coal black

Importation and Distribution in America The first importation

of Dutch Belted cattle into America of which we have any record was made in 1838. A second importation was made in 1848. The animals from these two importations were scattered throughout Orange County, New York, where their descendants are to be found at the present time. A large herd was also imported and placed on an estate at Cornwall, Pennsylvania. The cattle of this breed in America today are nearly all descendants of these two herds. In 1840 P. T. Barnum imported a number of Dutch Belted cattle for show purposes, but he soon sent the cattle to his farm in Orange County, New York. In 1906, one heifer was imported, but prior to this date none was imported for a period of over 50 years, chiefly on account of the scarcity of the animals in their native land. Within recent years, animals of the breed have been exported into Canada, Cuba, Mexico, Brazil, and the Argentine.

In the United States, Dutch Belted cattle are most numerous in the eastern states, especially New York, New Jersey, Pennsylvania, Ohio, and the New England states; a few are found in the South, and several small herds are to be found on the Pacific coast. There are about 6,000 head in the United States at the present time, with numbers steadily decreasing.

Dairy Characteristics. The cattle of this breed are fair milkers. A few cows hold records of over 400 pounds of butterfat per year. At the Pan-American Exposition at Buffalo in 1901, five Dutch Belted cows were entered in the cow test in competition with the same number of cows of nine other breeds, and while the five cows of this breed came out last in the test, they made a very creditable showing. The average production per cow for this breed was 4,978 pounds of milk and 169.4 pounds of butterfat during the six months' trial. The average percentage of fat was 3.4. One breeder in New York, after keeping yearly records for eight years, reports that twenty-five cows and heifers averaged 9,000 pounds of milk for one year. A New Hampshire breeder reports eleven cows in his herd which made an average of 8,579 pounds of milk in one year. One cow in this herd produced 12,672 pounds of milk in one year and 60,297 pounds in a period of six years, with an average butter production during the same length of time of 596 pounds.

Registration and Advanced Registry. The Dutch-Belted Association, which was organized in America in 1886, has registered between 3 000 and 4,000 animals In Holland the cattle of this breed are registered in the Netherland General *Stamboek*, published at The Hague

A system of making and recording official tests was adopted in 1912 The rules are much the same as those formulated for other breeds Up to the present time the number of official records made is small

FRENCH-CANADIAN

Origin The French-Canadian breed is descended from the native cattle of the provinces of Normandy and Brittany, France, and on this account is very closely related to the Guernsey and Jersey breeds

The French settlers who came from these French provinces and settled in Quebec, Canada brought their cattle with them and have bred and improved them under the existing conditions and environment for more than 250 years The cattle have become adapted to severe climates and are noted for their vigor and ability to withstand the cold winters of the North

Characteristics In size and conformation they are very much like the Jerseys and Guernseys, the cows averaging about 700 to 900 pounds at maturity They are active and well adapted to hilly and rough pastures In color, they are black, or black with a fawn or orange-colored stripe down the back and around the muzzle In quantity of milk they compare with the Jersey, and the fat content averages between 4 and 5 per cent

The French-Canadian Herd Book was established in Canada in 1886 Cattle of this breed are found mostly in the Province of Quebec, but also in small numbers in other parts of Canada and in limited numbers in New York and the New England states

KERRY CATTLE

Origin. The Kerry, the smallest of all dairy breeds except the Dexter, originated in southern Ireland, where it has been bred for centuries Very little is known of the history of this breed prior to the middle of the eighteenth century

The breed has been developed by the small farmers in Kerry County—tenants, in the main. The Kerry is of a distinctly dairy type. The color is a solid black, although a small amount of white appears on the underline of some cows. The upstanding horns are rather long and slender, with black tips.

Characteristics. The Kerry cow weighs not over 900 pounds, and the bull about 1,000 pounds. As a breed they are slow to mature, but they are vigorous and well adapted to severe weather conditions and are usually good grazers on scanty pastures.

Kerry cows in Ireland are said to produce from 5,000 to 6,000 pounds of milk yearly, while records of 10,000 pounds have been made. In tests supervised by government authorities in Ireland several records of between 7,000 and 8,000 pounds of milk in a year have been made. The fat content averaged about 4 per cent. Few animals of this breed have been brought to America and bred here, and these not primarily for commercial milk production but for special show purposes.

DEXTER CATTLE

Origin. Dexter cattle are native to the same locality in Ireland as the Kerry, from which they are an offshoot, and are so closely related to the Kerry cattle that only in recent years have the two been kept distinct.

Characteristics. The characteristics of the Dexter are similar to those of the Kerry except that the type is more like that of the dual-purpose animal. The legs are very short, the body well rounded, and the head plain, with horns similar to the Kerry. The color is solid black.

In size the Dexters are about a hundred pounds below the Kerrys, the cows averaging 600 to 700 pounds. Under government supervision cows of this breed in Ireland have produced up to 8,000 pounds of milk in a year with fat content of about 4 per cent.

DEVONS

Origin. The Devons are commonly classed as dual-purpose cattle. They are one of the oldest breeds that originated in Great Britain.

Very little is known of their early history, but it is generally believed that they are related to the Hereford and Sussex breeds Some writers believe that the latter breeds descended from the Devons The Devons were bred and developed in Devonshire, England, and they are divided into the North and South Devons The North Devons represent more nearly the original and true type of the breed The Quartly family of North Devon was largely responsible for the development and improvement made with the Devons While members of this breed are classed as dual-purpose animals today, they were bred originally for milk, beef, and draft purposes in their native country The cows average about 1,000 pounds in live weight, and are hardy, strong and active In color they are deep red White markings may appear on the belly and on the udder The horns are long, and turn upwards and backwards

The Devons were first introduced into America in 1817 and a number of importations were made at later dates They were at one time popular in the eastern states, where classes for them are still maintained at certain livestock expositions In recent years other breeds have come into public favor more strongly, and the Devon breed has lost ground

Characteristics The dairy characteristics of the breed have never been very highly developed, like other dual-purpose animals, they give a large quantity of milk at the beginning of their lactation period but are not persistent milkers In a report made by the New York Experiment Station the average butterfat test for 72 head of cattle was 4 15 per cent Yields of 5,000 pounds of milk per year have been reported No official milk and butter records have been reported

The interests of the Devon breed are looked after in America by the American Devon Herd Book Association The first volume of the Herd Book was published in 1861

RED DANISH

This breed has received widespread popularity in northern Europe It is the popular breed of Denmark and recognized for its high average production It is one of the newest breeds to be developed, its development having taken place largely in the past hundred years

Its ancestry is largely from the red cattle found in the marsh lands of northern Germany and south Denmark. This early ancestry is probably much the same as the early ancestry of the solid red cattle of England, as it is believed that these came from the marsh lands of northern Europe. The Red Danish was first imported to the United States in 1935 by E. L. Anthony for the United States Department of Agriculture, for experimental breeding purposes. Since its importation the United States Department of Agriculture has kept all the purebreds of this original importation of twenty females and two bulls under its close control and supervision. A number of different types of crossing and upgrading experiments have been made and are found in recent reports of the Bureau of Dairying of the United States Department of Agriculture. Purebred bulls have been loaned to farmers in several states for crossbreeding and upgrading. The most widely spread of these is found in northeastern Michigan, where there are now more than 6,000 of these cattle. They have been rather popular and a new cattle breeders' association has been organized to register this breed. An open herd book is used with very exacting qualifications as to production records of all females for four generations, and other qualifications. These qualified cattle are in much demand and are being sold to breeders in other states. Good showings of this new American breed have also been made at the Michigan State Fair The American Red Danish Cattle Association is located at Fairview, Michigan.

CHAPTER X

Dual-Purpose Cattle

GENERAL DISCUSSION

Definition of the Term The term "dual purpose" is used to describe those breeds of cattle which are bred for both milk and beef production in contrast with those called "special-purpose," which are bred primarily for either milk or beef However, the question of beef production in connection with that of milk is largely one of degree, since practically all dairy cattle are used for beef when their period of usefulness as milk producers is at an end This has been especially true for centuries in Europe where all the cattle in the United States originated True dual-purpose type is difficult to develop and maintain by different breeders

Much of the discussion regarding the question of dual-purpose as compared with special purpose cattle comes from erroneous ideas of what constitutes a dual-purpose animal The man who is interested primarily in milk production is inclined to call every cow that does not produce milk profitably—especially if she shows a tendency toward beefiness—a dual-purpose cow The cow in question might more often be correctly classed as a no-purpose cow Other dairymen go to the other extreme, and call such cows as the Holstein dual-purpose because they have some value for beef production

Standards for Dual Purpose Type The true dual purpose type stands about midway between the extremes of the dairy type, or large milk producers, and the beef type, with little tendency toward milk production A dual purpose cow is one that produces a medium quantity of milk for a dairy cow and will fatten readily and sell at a fair price for a beef animal A dual purpose breed is one in which

these characteristics are so fixed that they are transmitted with reasonable certainty. There is occasionally a dual-purpose Angus or Hereford cow; but these instances are sporadic and these breeds cannot be so classed, for the reason that they do not transmit this characteristic. Again, we find cows in the dual-purpose breeds that are such remarkable milkers and that show such inferior beef-making characteristics that they should be classed individually as special dairy animals, and not as dual-purpose. There is such a thing as a dual-purpose cow, if we correctly define the limitations of the term. It must not be expected that a cow of this type will compare as a dairy animal with good individuals of the special dairy breeds, or that her calves will be able to compete in beef production with those of the special beef breeds. A dual-purpose cow should be expected to produce about 300 pounds of butterfat per year against about 350 pounds for an equally good specimen of the dairy breed; and her calves should make fair beef animals.

Adaptation of the Dual-Purpose Cow. The question of whether the farmer should breed special-purpose dairy cattle or dual-purpose when dairy products are sold from the farm is one that has called forth endless discussion. The view represented by one extreme is that if a cow is to be milked at all, she must be of a special dairy breed, and that no such thing can exist as a profitable milk and beef producer combined. The other extreme holds to the view that the average farmer, who produces the largest bulk of the dairy products of the country, can make the best use of a cow that will produce a fair amount of milk and at the same time raise a calf which will be salable for beef purposes.

The question can best be considered by eliminating the points upon which there is practically no difference of opinion and by concentrating attention upon the points where there is a chance for difference of opinion.

1. It is generally admitted by all that cows of the special dairy breeds will, on the average, produce more milk and butter, and produce it cheaper, than those of dual-purpose type; and that the special beef breeds excel the dual-purpose in beef production.
2. The man who intends to make dairying his chief business, with everything else of secondary order, should make use of the special dairy

cow, and the man who produces beef animals and does not milk the cows should make use of the special beef breeds

3 The highest development of both milk and beef production cannot be combined in the same animal

Dual Purpose Cows for the General Farm. This leaves the general farmer for whom the dual-purpose cow is adapted, if for anybody This large class of farmers, especially in the Central states, are often not close to fluid milk markets, and change their farming operations from year to year to meet the changing price levels They do not specialize in any particular thing and sell a number of things from the farm, among which milk or cream occupies a more or less important position

The main question regarding the dual-purpose cow is whether this type is better adapted than the special dairy breed for such a farmer If this general farmer, who is using dual-purpose cattle, is asked why he does not use special-purpose dairy cattle in preference to the dual-purpose, he will give one or all of the following reasons

1 The calves from the dairy breeds are not salable for beef purposes
2 The cows of the dairy breeds are not salable for beef when they are no longer useful for milk production
3 The cows of the dairy breeds are delicate and require better care and attention than he can give them

There is some ground for these statements The calves of the dairy breeds, as a rule, cannot be raised for beef with profit, and it is often unprofitable even to raise the males for veal

It is also true that cows of the dairy breeds bring a low figure in relation to the current market price when sold for beef, and when herds are properly weeded out, it is necessary to dispose of a considerable number of cows every year On the other hand, profitable dairy cows, once secured, are usually kept at a profit for a comparatively long time, and the difference in return for the milk produced by a cow of the dairy breed and of the dual-purpose breed far more than makes up for the difference in beef when placed upon the market It is also true that cows of the dairy breed need good attention, or they will not be kept at a profit However, it cannot be said that they are especially delicate, although they will be of little value

if allowed to go without proper shelter and food. The dual-purpose cow that produces milk for a few months during the summer only is better adapted than the highly developed dairy cow for the farmer who will not provide the proper conditions. It requires good, intelligent care to make use of so highly developed an animal as the modern dairy cow; the farmers who are not able to meet these requirements might as well let her alone.

Regional Preference for Dual-Purpose Cattle. There is more to recommend the dual-purpose cow in the corn belt than elsewhere, and here the type is the most numerous. The typical farmer of this region finds it impractical to secure sufficient labor to carry on a herd of dairy cows large enough to utilize the feed—especially the roughage—grown on the farm. The raising of a number of beef cattle allows surplus roughage, which cannot be put upon the market with advantage, to be utilized with small additional labor.

The dual-purpose cow also serves a useful purpose in many cases as an intermediate step in changing from a system of beef production to milk production when conditions make such change necessary. That is, when the farmer who has been engaged in beef production begins to sell dairy products, he usually milks the cows he has for a time, then gradually changes toward a dairy type by using dairy-bred sires. In this way he gains experience in handling dairy cattle gradually as the herd is developed.

Difficulties in Fixing Dual-Purpose Type. Fully as many difficulties are experienced in breeding dual-purpose cattle as in breeding special-purpose dairy cattle. One of the tendencies observed is for individual breeders to emphasize either the beef or the milk production side, instead of keeping the two of about equal importance. This practice results in dual-purpose breeds varying much in type as bred by different breeders. The judging of dual-purpose cattle in the show ring is often unsatisfactory on account of the lack of a definite standard for such types, and the tendency of many judges is to minimize either the beef- or milk-producing characteristics.

MILKING SHORTHORNS

Origin and Development. This breed takes its name from its characteristic short horns. It is also incorrectly called the Durham in

some localities, from one of the counties in which it originated The original home of the breed is in northeastern England, in the counties of Durham, Yorkshire, and Northumberland, especially in the valley of the River Tees In this region the breed was improved and developed, and from here it has spread over almost the entire civilized world

The exact origin is veiled in obscurity The Romans, Saxons, Danes, and Normans in succession brought their cattle to England and mixed them with the native stock After the invasion of the Normans there was little interchange of cattle for several centuries, during which time the animals in the rich valley of the Tees probably increased in size, owing to the favorable conditions of climate and food and the superior skill of the herders in that section in selecting and mating their herds

Influence of Other Breeds It is known that a large type of cattle existed in this region several centuries before the development of the modern Shorthorn in the eighteenth century Early in the eighteenth century several bulls were brought from Holland and used in some of the herds from which descended the improved types of Shorthorns

Noted Early Breeders The beginning of the improvement which resulted in the modern Shorthorn began about 1780, when Robert and Charles Colling, English cattle breeders, began their breeding operations, which lasted until 1818 These men are often spoken of as the founders of the modern Shorthorn breed Shorthorns as bred by the Colling brothers were generally good milkers, and this quality was considered by them an important characteristic of the breed, to be retained as far as possible At the same time, they were more interested in developing the general symmetry, early maturity, and beef making characteristics They followed the methods of Robert Bakewell closely, practicing inbreeding constantly

Toward the latter part of the eighteenth century, Thomas Bates, another English breeder began breeding Shorthorns He aimed constantly to develop a superior combination dairy and beef animal, and he succeeded to a marked extent Most of the best milkers among the Shorthorns at present are descended from animals of this breeding

The Booth family began to breed Shorthorns about 1790 They

emphasized beef production, and paid little or no attention to the dairy qualities

Amos Cruickshank, who began breeding in 1837, developed the so-called Scotch type of Shorthorns, which are characterized by superior beef qualities and decidedly inferior dairy qualities

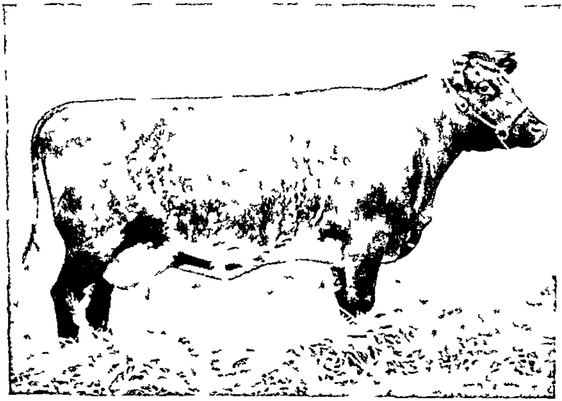

FIG. 24 Typical Milking Shorthorn cow Ingleside Roan Model Three times winner at International Livestock Show Owned by H E. Powell and Son Ionia Michigan (Courtesy of H E Powell and Son)

The original Shorthorns were counted good dairy animals Some very creditable reports are given regarding daily or weekly production of certain cows in the time of the Collings It would appear, however, that even then the breed had the characteristics of some Shorthorns of today milking heavily for a short time but lacking persistency

Influence of Early American Development The Shorthorn cows brought to America during the early importations were usually at least fair milkers, and some were exceptional On account of the early use of this breed for exclusive beef production in America, the dairy qualities were generally neglected and most breeders aimed only at the best beef animal This condition was further strengthened

by the importations of the Scotch type As a result, most purebred Shorthorns as found today in America as a rule have no claim whatever to be called dairy animals In certain herds the original dairy qualities have been preserved These herds now form the foundation for the American Milking Shorthorn Association Within recent years there has been a revival of interest in the milking qualities of this breed, and a considerable number of herds of purebred milking Shorthorns are now to be found where all cows are milked and records of individual production are kept

Breed Characteristics The milking Shorthorns vary in type from the beef conformation to the dual-purpose, with the real dairy form the desired type The latter as yet are not predominant, although great progress has been made in recent years since the separation of Shorthorns into the distinct dairy and beef types Shorthorn cows of the milking types weigh usually between 1,200 and 1,350 pounds when mature A typical milking cow loses considerable flesh when in milk, when dry she fattens rapidly, and shows some of the beef characteristics Red, white, and roan are the typical Shorthorn colors, and the disposition is quiet and gentle The reproductive functions are only medium More difficulty is experienced with failure to breed than with certain other breeds and the calves at birth are only medium in vigor At birth, calves range between 70 and 80 pounds in weight and represent about 6 per cent of the weight of the dam

Dairy Characteristics While the milking Shorthorns are still less prominent among the dairy breeds nevertheless enormous numbers of grades of this breed are milked, especially in the butter producing states of the Mississippi Valley As in the case of other breeds, it is difficult to get satisfactory data concerning the production of Shorthorn cows under practical farm conditions A compilation of records published by experiment stations shows an average of 6,017 pounds of milk and 218 pounds of fat in a year for thirty-seven animals represented The average percentage of fat for these animals is 3 63, and of total solids 12 85 These figures are about typical of results in herds in which careful attention has been paid to selection of the individual animal, and in which good conditions of feeding and man-

agement are maintained. Such an average is considerably higher than that realized on the ordinary farm. From the data available it is safe to say that a herd of dairy Shorthorns should be expected to average between 5,000 and 6,000 pounds of milk and from 250 to 300 pounds of fat. A high figure for a herd average would be 6,500 pounds of milk or more, while less than 5,000 pounds as an average indicates lack of care in selection of individuals or improper conditions of feeding and management. The fat content will vary as a rule between 3.50 and 4.25 per cent with an average of not far from 3.8 per cent.

Persistency in Production. The milking Shorthorn cow, like others of the more dual-purpose breeds, generally vary in milk production. It is not uncommon, for example, that a Shorthorn cow produces 40 to 50 pounds of milk a day when fresh, but declines so rapidly after four or five months that her total product for the year may be not over 4,000 and in seven or eight months she may be dry. There are notable exceptions to this by certain individuals of the breed which show all the persistency in milk production of the more highly developed dairy breeds. Perhaps the most marked difference between herds that show a low to a medium production and those that under the same conditions show a high production is a difference in persistency of milk flow. In color of milk and in size of fat globules, Shorthorn milk ranks between that from the Channel Island breeds and the Holstein breed.

Shorthorns in England. The dairy Shorthorn is the principal dairy cow of England today and the typical Shorthorn cow of England, as well. Professor Long says: "The milk-producing farmer has studied how to increase the flow of milk while maintaining the characteristic feeding qualities of the breed, and has succeeded. On the other hand, the great pedigree breeders have subordinated milk to flesh development, form, quality, and even color. Where sires and dams are of equally renowned milking character, the Shorthorn is preeminently the best dairy cow in the best dairy country in the world."

The milking qualities of the English Shorthorn are shown in a re-

markable way by the results of the milk and butter tests made at the London Dairy Show During recent years, first place in both milk and butter production has been won in a majority of cases by either a registered or a nonpedigreed Shorthorn Two hundred and thirty-six pedigreed Shorthorns in these tests averaged 48 pounds of milk and 1 82 pounds of fat a day One hundred and twenty-six nonpedigreed Shorthorns averaged 51 8 pounds of milk and 1 95 pounds of fat a day

Breed Organizations The registration of purebred animals of the Shorthorn breed for many years was in the hands of the American Shorthorn Breeder's Association, with headquarters in Chicago

In 1910 a group of Shorthorn breeders interested in developing the milking strains of the breed organized the Dairy Shorthorn Breeders' Association, which functioned as an auxiliary to the American Shorthorn Breeders' Association

In 1915 another group of breeders, who believed the interests of the milking Shorthorns could be best served by a separate organization, established the American Milking Shorthorn Breeders' Association Another object in view was to make it possible to utilize the nonpedigreed Shorthorn of England, which included the best developed dairy types of the breed but which had not been imported to the United States because the American Shorthorn Association accepted only those imported animals registered in the Coates Herd Book of England.

This organization later was discontinued and the American Shorthorn Breeders' Association again had full responsibility for the promotion of the breed s welfare The Milking Shorthorn Society, formed in 1920, an active organization of those interested in Shorthorns of the milking strain, published a journal for its members and acted in an advisory capacity to the parent organization Again in 1948, a separate organization representing the Milking Shorthorns with a separate herd book was established The American Milking Shorthorn Society is now located in Springfield, Missouri, and is very aggressive in the development and promotion of this breed In 1954, 21,834 were registered The leading states are Iowa, Illinois, Kansas, and Minnesota

Advanced Registration. Some years ago the Shorthorn Breeders' Association established an advanced register planned somewhat along the same lines as those in use by the special dairy breeds. At present three classes or divisions are used. Of these Class A is for authenticated records made under the same rules as official testing in other breeds. Class B is for records in Herd Improvement Associations, and Class C for private records which have been subjected to a limited amount of inspection. In addition there is a 305-day record division known as double letter classification. There is also an Advanced Record of Merit for both bulls and cows.

Some Leading Milking Shorthorn Records

COW	LBS MILK	LBS FAT
Ruth B 568209	21,641	956.7
Mountain Princess 1635668	21,023	853 5
Bonnie Rose Meade 1284440	20,429	785 5
Butter Girl 655609	20,325	698 2
White Molly 1415398	18,346	806 0

The highest production for the breed is credited to Melba 15th of Darbalara, owned in New South Wales, Australia. This record is 32,522 pounds of milk and 1,614 pounds of fat in a year. A number of other excellent records have been made in the same herd. In recent years several Dairy Shorthorns in England have exceeded 20,000 pounds of milk in a year.

The Milking Shorthorn Society is located at 313 South Glenstone Street, Springfield, Missouri.

RED POLLS

Origin and Development. This breed originated in Norfolk and Suffolk—adjoining counties in the eastern part of England. These counties are low and flat, with some marsh land. The soil is naturally diversified, although rather poor, but it has been brought to a high state of fertility by good management. About 80 per cent of the area is tillable. The climate is generally typical of England, although the rainfall, which averages twenty-six inches per year, is less than the average for England.

The history of this breed, like that of most other breeds, is uncertain It seems, from the best information obtainable, that they have been bred up from the cattle native to these two counties since a time more remote than accurate historical records go Improvement began in the latter part of the eighteenth century, as part of the widespread movement of that time for improved livestock

Mr Euren, the first Secretary of the Red Polled Herd Book, is of the opinion that the original cattle of this type were brought to England by the Danes who settled in this part of England in the fifth century There can be no doubt as to the similarity of characteristics of the cattle found in the southern provinces of Jutland and the red cattle of England He does not believe there is any foundation for the statement often made by writers that Galloway blood was introduced from Scotland by bringing Galloway bulls However, Youatt, the well-known early English writer on cattle, and Wallace, a recent writer, attribute the improvement largely to this source

Development of Polled Character In 1804 Young wrote an account of the agricultural conditions in Norfolk and Suffolk, in which he described the cattle of Norfolk as a small, red class of cattle, partly polled and partly horned At this time they were bred more for beef than for milk, and made a poor impression on the writer Later, the horns were bred off by using, probably, either Suffolk or Galloway bulls for the purpose The beef qualities were considerably developed according to some authorities, by introducing Devon blood In 1818 the cattle of Norfolk began to be known as Norfolk Polled

The cattle of Suffolk from the earliest records were considered exceptional milkers They were rather small in size, red, brindled, dun or mouse-colored, and always polled Young, writing in 1804, describes them as follows A clean throat with little dewlap, a clean head, thin legs, a very large barrel, ribs tolerably springing from center of the back, but with a heavy belly, backbone ridged, chine thin and hollow, loin narrow, udder large, loose and creased when empty, milk veins remarkably large A general habit of leanness, hip bones high and ill covered with flesh "

According to the same writer, yields of five gallons of milk per day

were not uncommon for entire herds while on pasture. The breed had the reputation of being the heaviest milkers in England for their size, and of being especially adapted for poor pastures and unfavorable surroundings. The Suffolk cattle were always bred mostly for milk. The cattle of this county became known as Suffolk Polled. The colors other than red were bred out during the early part of the nineteenth century.

The cattle of Suffolk and Norfolk were developed along the same lines; about 1846 it was generally recognized that the two types were so near together that they were practically the same. The division in name continued until 1862, when at the Royal Agricultural Society Show they were first classed together under the name, Norfolk and Suffolk Polled. In 1882 the name was shortened to the present name of Red Polled.

At the present time the breed is found largely in the two counties where it originated and to some extent in Australia and New Zealand. They are not found on the Continent. They are used in England as dual-purpose cattle, and in that class rank about the same as the nonpedigreed Shorthorns.

Importation and Distribution in America. Cattle from the home of the Red Polled breed were undoubtedly brought to America during the colonial days, but they were not kept pure. These early importations are probably responsible for the muley red native cows often seen, particularly in the eastern states, some years ago. The first importation of the improved type was brought to America in 1873 by Gilbert F. Tabor, of Patterson, New York, who also made several later importations. Several importations were made between 1880 and 1890, and from these mentioned are descended most of the cattle of this Red Poll breed now in America.

They are now found in all, or nearly all, the states of the Union, but they are most numerous in Ohio, Illinois, Michigan, Iowa, Wisconsin, and Kansas. The English Red Polled Herd Book was first issued in 1874. The Red Polled Cattle Club of America, organized in 1883, registers the breed for America.

They have won their way entirely upon their merits, and are in-

creasing rapidly in those states where dual-purpose cattle are in demand They are the most typical and most popular of the real dual purpose breeds

Breed Characteristics In size, the Red Polls rank below the Shorthorn and other heavy beef breeds The cows weigh between 1,200 and 1,300 as a rule, but occasionally one reaches 1,500 or more The bulls range from 1,800 to 2,200, and occasionally individuals reach 2,500 at maturity

In color, the Red Polls are a deep cherry red White may appear on the tip of the tail, the udder may be white, and a few small white markings are allowed on the belly White on any other part of the body disqualifies the animal, as does a black nose or even abortive horns

In form, the Red Polls are typical dual-purpose cattle In general, the conformation is about midway between the dairy and beef types as typical of the dual-purpose breeds The general form is parallelogrammic The head and neck are lean and of dairy type, with the characteristic poll The hind quarters are of moderately good beef form The udder is often somewhat pendulous, and the fore quarters frequently deficient and irregular in shape The udder is seldom meaty in character, but usually elastic and mellow in quality The milk veins and milk wells are usually fairly prominent The teats are inclined to be irregular in shape, and often large, even to the extent of being somewhat objectionable at times

There is considerable variation in type between different herds of this breed, depending upon the purpose for which they have been bred In some cases they are bred for beef production alone, and the cows are then not milked In other herds the dairy qualities are given first place Such practice results in wide variations in form and capacity for milk production in different herds The judging of Red Polls in the show ring has usually been done mainly from the beef standpoint, which tends to develop the beef qualities at the expense of the milking qualities The Red Polled Cattle Club has formulated a scale of points to assist in establishing a more definite type

Red Polls are fair breeders, ranking about equally with the Short-

horns in this respect. In regard to early maturing qualities they probably rank rather lower than the Shorthorns.

Beef Production. The Red Polls are a real dual-purpose breed, according to the definition given, since they are relatively uniform in their ability to produce a fair amount of milk and are salable for beef at a creditable price.

As compared with the beef Shorthorns found in America, the Red Polls are, on the average, superior milkers, while as regarding beef production the conditions are reversed. The breed ranks well as beef producers, but does not win highest honors in competition as beef animals. The steers are satisfactory feeders; they gain rapidly and bring a creditable price. The steers are not so blocky and compact as those of the strictly beef breeds, and usually they are longer legged. The cows fatten rapidly when they are not producing milk.

Milk Production. Red Polls rank high in milk production for a dual-purpose breed. Few records have been published of cows owned by experiment stations, but those available show a yearly average of 5,900 pounds of milk having a fat test of 4 per cent, equivalent to a fat yield of 236 pounds. Under good farm conditions a herd of Red Polled cows should average yearly from 5,000 to 6,000 pounds of milk and from 200 to 250 pounds of fat. Good specimens should be expected to produce up to 10,000 pounds of milk in a year. In yield of milk this breed is excelled by the Holstein and Ayrshire, and in England by the Dairy Shorthorns.

Milk of the Red Polled breed has about the proper composition to make it most suitable for market purposes or cheese-making. In color of milk and butter it ranks about equal with the Shorthorn, below the Jersey and Guernsey, and above the Holstein and Ayrshire.

Advanced Registry. A plan for making official records was adopted by the Red Polled Cattle Club in 1908. The tests are conducted, as in the case of the other breeds, under the supervision of a representative of the Agricultural College in the state where the herd is located. The supervision covers two days of each month, the owner keeping the milk record between the test periods. The number of cows tested for advanced registration has not been large as compared with

the numbers from the dairy breeds, but the records made have been very creditable and have exerted a marked effect upon the popularity of the breed Among the leading cows of the breed in milk production is Jean Du Luth Beauty, with a production within a year of 20,280 pounds of milk containing 891 pounds of fat This cow weighed 1,750 pounds at the completion of the test Thirty animals owned in the same herd as the record cow had official records averaging 460 pounds of fat a year

CHAPTER XI

General Considerations in Selecting a Breed

The Choice of a Breed. The first question which arises in starting a herd is the choice of the breed. There is a tendency to attach too much importance to this decision. It is the capacity and ability of the dairymen, and not the breed, which largely determines success with cattle. The important thing is to decide upon the breed after weighing all the facts available, and then to continue with the one chosen unless some unusual condition arises which justifies a change. Minimizing the importance of breed selection should not be interpreted as signifying that breeds as such are unimportant. Quite the reverse is true. It has been pointed out in a previous paragraph that breeds represent the efforts towards improvement by generations of breeders and that the use of a well-established breed makes it possible to take advantage of all that has been done in the past and to start on a par with those at present engaged in this work. Warning is also given elsewhere against the indiscriminate crossing of breeds, as it is a practice which more often leads to deterioration of the herd rather than to improvement.

The leading dairy breeds, however, do not differ much in real efficiency, as shown in a later paragraph. If one farmer has not made a success with dairy cattle and another has made a marked success, the difference in outcome is seldom to be attributed to the choice of breeds. The man who is a failure with one breed ordinarily will meet

a similar fate with another The success or failure of a dairy-farming enterprise is seldom to be attributed to the breed chosen but usually to other causes, such as failing to cull out unprofitable cows, and improper methods of feeding and management

Factors Determining Breed Selection There are certain considerations which may be taken into account in choosing a breed and the most important may be listed as follows

1 Breed of cattle most common in the community
2 Form in which product is to be marketed
3 Average production of milk and fat
4 Original cost and probable demand for surplus animals
5 Climate food supply, and topography of farm
6 Economy of production of milk and fat
7 Breeding qualities of the cows
8 Vigor of calves
9 Beef value of discarded cows and adaptability of calves for veal
10 Preference of the breeder

Most of these points have been discussed in greater detail in connection with the descriptive matter concerning the breeds

The advantages to the farmer of using the same kind of stock as his neighbors should be given far greater prominence than his own preference or any small points of difference between the breeds

Markets a Factor in Breed Selection If the farmer expects to sell milk on the wholesale market, his choice would hardly fall upon the Jersey or Guernsey unless the market is the exceptional one that will pay enough more for rich milk to justify its production For milk production the Holstein, Brown Swiss or Ayrshire would come into strong consideration on account of their large and economical milk production If the location is such that cream will be sold, the Channel Island breeds should receive careful consideration on account of their well known economical use of feed for the production of butterfat Under these conditions the probable value of skim milk for pigs and calf feeding is still another consideration and might cause the choice to fall upon the Holstein on account of the large production of this valuable by-product In the sale of butterfat or cream, the total quantity of fat and not the percentage of fat in the milk is

the important factor. For cheese-making and for market milk the total solids and not fat alone are wanted.

It is impossible to give figures that are satisfactory regarding the relative production of the breeds under practical farm conditions. The results from official testing are available but represent conditions far removed from those existing among the herds where the great mass of market product is produced. It may safely be said that, between the breeds, the variation in average production is not great, and it is far less than that between the good and the inferior animals within the breed or between good and poor dairymen using the same breed.

The *original cost should receive some consideration but can be* easily overemphasized, since the herd is ordinarily maintained by raising young animals; the probable demand for surplus animals is difficult to estimate in advance. It does suggest, however, the desirability of using a breed well known to the public and one popular in the region where the herd is located.

Adaptation to Region. Facts concerning the relation of the breeds to abundant pasturage, hilly pastures, and warm climates have been given in connection with the individual breeds. The economy of milk and fat production is closely related to the form in which the product is to be marketed and should be considered in that connection. It is well to keep in mind that the breeds having the largest average production are the cheapest producers as well. The breeding qualities of the cows and the vigor of the calves are important and should receive due consideration. The beef qualities of discarded cows and the adaptability of the calves for veal are of minor importance in a herd representing a special dairy breed. A difference of even $25 in the beef value of a discarded animal is a small consideration, if in order to get this additional return an inferior cow has been kept four or five years with possibly a greater loss in milk production each year than her additional beef value would be when discarded.

The individual preference of the man who is about to start a herd should not weigh too heavily in making a choice, since a person who is a born stockman will soon prefer the breed with which he is working, and his preference will change quickly, as a rule, if a breed is selected which was not his first choice.

The Relative Efficiency of the Breeds In presenting the merits of a breed, its adherents often make claims of special efficiency in the matter of fat production or milk production as the case may be The idea is often held that one breed or another in some way makes better use of its food than others It is a simple matter to analyze the situation, to show how much truth lies in such claims, and to give an explanation of such of these statements as can be substantiated In order to understand the questions involved it is necessary, however, to have certain fundamental facts clearly in mind

Between high and low producers It is well known that there is a wide contrast between a heavy-producing and a low-producing cow in the amount of food required to produce a pound of milk or fat

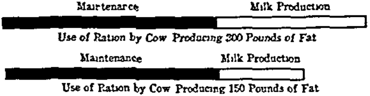

FIG. 25 The economy of high fat production The cow producing 300 pounds of fat uses only about 25 per cent more feed than is required to produce 150 pounds by a cow of the same size

The explanation in detail is reserved for a later chapter, but it must be anticipated to some extent at this point An animal that produces 300 pounds of fat in a year does so at a lower feed cost per pound of fat than does an animal of the same size and breed producing 150 pounds The heavier producer uses more feed but less in proportion to her production The explanation is that the feed used to maintain the animals—that is, keep up the body—is the same for both The heavier producer has a greater capacity for work and after supplying her own maintenance uses more feed for making milk than does the small one

Fig. 25 will assist in conveying these facts This graph illustrates the division of the ration between maintenance and milk production for two Holstein cows of the same size, one producing 300 pounds of fat, the other 150 pounds in a year It will be noted that the additional feed used by the heavier producer all goes to milk produc-

tion, and while she uses a greater quantity of feed, the amount to the pound of fat is evidently decidedly less.

Maintenance requirement in proportion to size. It is well established that the feed necessary to maintain a dairy cow—that is, to preserve a uniform weight when no milk is produced—varies with the size of the animal. According to the earlier German feeding standards, the maintenance requirement was stated as in direct proportion to the weight. Armsby, however, found that this is not exactly the case, the smaller animal having a slightly higher maintenance requirement in proportion to size. This difference is so small, however, that it may be ignored in a practical consideration. From this point of view a cow weighing 900 pounds will require three fourths as much feed for maintenance as will one weighing 1,200 pounds.

Breed differences in digestion of feed. The evidence available shows that the breed of the animal has no relation to its ability to digest food. In an experiment by the author a digestion trial was made with cows representing four breeds and receiving exactly the same ration. The results were as follows.

	PER CENT DIGESTED
Holstein	65.34
Ayrshire	64 31
Jersey	66 27
Dairy Shorthorn	65.52

It is surprising how close all came to the same figure. These results are, in fact, all within the limit of error, and the variations are too small to receive any attention. This is in line with the conclusion of Armsby, who states: "The recorded data fail to indicate any material difference in the digestive power of different breeds or between purebred and scrub animals."

Breed variation in cost of fat production. In the discussion of the Jersey and Guernsey breeds, it is pointed out that, on the average, cows of these breeds can produce a pound of butterfat at a slightly lower feed cost than can a Holstein or Brown Swiss. There are two reasons for this: (1) the most important is that the Jersey and Guernsey are smaller animals and the amount of feed required to

maintain the cow is less than for a Holstein or Brown Swiss (2). These breeds produce richer milk, in other words, they produce less milk along with the fat.

The author fed cows of different breeds for an entire lactation period upon uniform rations. From these data figures for individual cows are selected which illustrate in a typical manner the case as between the Jersey and the Holstein breeds.

	LBS WEIGHT	LBS MILK	LBS FAT	LBS DIGESTIBLE NUTRIENTS PER LB FAT
Holstein	1,219	11,986	407	16.1
Jersey	950	6,033	367	14.1

These data show that the Jersey used less feed to the pound of fat produced than the Holstein. The principal reason for this was that the Holstein, weighing 1,219 pounds, on account of her greater size required more feed for maintenance than the Jersey, which weighed only 950 pounds.

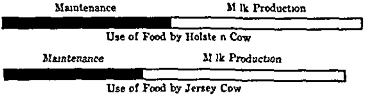

FIG. 26. Graphic illustration of the influence of the size of the animal as a *factor in economy of production. If two cows produce the same amount of* fat, the smaller cow will use less feed per pound of fat on account of the smaller maintenance requirement.

This is illustrated by Fig. 26, in which the black is the portion of the ration used for maintenance and the unshaded that used for milk production.

The difference between the 16.1 pounds of digestible nutrients used by the Holstein per pound of fat produced and the 14.1 used by the Jersey is thus to be attributed to a combination of a lower maintenance for the Jersey and less skim milk produced in proportion to the fat.

Breed difference in feed for milk produced. It is generally recognized that the Holstein breed is pre-eminent in economy of milk production, although, as in the case of the cheaper fat production by the Channel Island breeds, the importance of this fact is often overestimated.

In the data from the same cows, used in the comparison in the previous paragraph, the digestible nutrients to the hundred pounds of milk and per pound of total solids are as follows:

	HOLSTEIN	JERSEY
Pounds milk	11,980	6,033
Per cent fat	3.40	6.09
Digestible nutrients consumed per 100 lbs. milk	54.7	87.7
Digestible nutrients consumed per lb. total solids	4.8	5.6

The data show that the Holstein used 9.3 pounds of nutrients per day for maintenance, while the Jersey used only 6.2. If the feed required to the pound of fat is calculated, after taking out what was necessary to maintain the animal, it is found that the Holstein used 7.7 pounds of digestible nutrients to the pound of fat as compared with 8.2 pounds for the Jersey. This shows that the Holstein really was making as good use of her food as the Jersey. The reason the Holstein was using a trifle more feed for each pound of fat was mainly that she had to use more feed to maintain herself. It is clear that if a 950-pound cow will produce as much as one weighing 1,200 pounds, the amount required for a pound of fat will be less by the smaller animal.

The second factor influencing the feed cost of the fat also comes into account here. For each pound of fat in her milk the Holstein produced 2.3 pounds of other solids and the Jersey 1.6 pounds.

Feed is required for the production of the solids not fat—which may be thought of as skim milk in this connection—as well as for the fat. Since the Holstein produced more skim milk in proportion to her fat, the feed cost of milk—if all is charged against the fat—will tend to be higher for the Holstein. In this case it is clear there are two reasons for the cheaper production per 100 pounds of milk by the Holstein. These are the larger production and the lower percentage of fat. The lower food requirement for the production of total

solids by the Holstein as accounted for by the larger production in proportion to the size of the cow and the lower *proportion of fat in* the solids

General considerations When all the facts are considered, it will be found that the question of efficiency of breeds from the standpoint of feed requirements resolves itself largely into one of comparative size of the animal and yield of milk and fat To a minor extent the proportion of skim to fat—in other words, the richness of the milk—is involved If a small cow will produce as *much milk or fat* as a larger one, she will do it more cheaply, because there is less cow to maintain If the larger animal produces enough more milk than the smaller cow so that the proportion of her ration used for maintenance is no larger than with the smaller, the feed cost per pound of fat will be just as low In the case of two animals of the same size which produce milk of the same quality, the larger production, although it calls for more feed, is bound to be the cheaper

The main difference in the efficiency of cows as milk and fat producers is the difference between the low producer and the high producer, and bears no relation to breed There *is no known difference* in the efficiency of breeds so far as digesting feed is concerned or in the use of feed as a whole if everything is taken into account Individual differences will be found within the breed *which are equal to or* greater than any breed differences which may be cited Some animals require more for maintenance on account of greater size, others, by producing milk low in fat, use *more feed for production of solids not* fat.

The Channel Island breeds are producers of cheap fat, first, on account of their smaller size in *proportion to the amount of fat* produced, second, because of the smaller amount of skim milk, or solids not fat, produced along with the fat

The Holstein breed produces milk at the least *feed cost* per 100 pounds first, on account of the larger milk yield which overbalances the higher maintenance costs, second, on account of the lower fat percentage—that is, the smaller amount of fat in proportion to the total milk produced

Breed differences in the use of roughage The statement is often

made that a marked difference exists in the utilization of roughage by different breeds. Superiority in this respect is generally claimed for the Holsteins by partisans of this breed. Clearly there is no advantage in the consumption of large quantities of roughage unless the need for concentrates is correspondingly less. The real question therefore is the possibility of one breed having the ability to utilize roughage to the extent of securing a larger proportion of its nutrients from this source.

Experimental results. Woll[1] studied the records of feed consumed and milk and fat produced by a large number of cows entered in the Wisconsin Dairy Cow Competition. Presumably the best herds in the state were represented and the owners used their own judgment as to feeding practice. Woll made his calculation in terms of "feed units." The source of the feed units as between the roughage and concentrates was as follows.

NUMBER OF COWS	BREED	AVERAGE YIELD OF LBS FAT	PERCENTAGE OF FEED UNITS FROM ROUGHAGE
50	Holsteins	524	47.6
50	Guernseys	432	53.1
50	Jerseys	371	59.8

In this case the proportion of nutrients from the roughage was decidedly less for the Holsteins than for either the Jersey or the Guernsey. But this is to be accounted for by the higher production, since it is a well-established fact that the higher the production of milk and fat, the greater the proportion of nutrients that must come from concentrates. The twenty-five poorest Holsteins with a production of 374 pounds of fat may be compared with the fifty average Jerseys producing 371 pounds of fat. In this comparison the Holsteins derived 51.3 per cent of their nutrients from roughage and the Jerseys 59.8.

A comparison from feeding records reported by Savage[2] shows that five Jerseys producing on an average 1.29 pounds of fat daily derived 51 per cent of their total nutrients from roughage compared

[1] Wisconsin Agricultural Experiment Station Research Bulletin 26 (1912)
[2] Cornell University Agricultural Experiment Station Bulletin 323 (1912)

with 52 8 per cent from roughage by a group of Holsteins producing on the average 1 33 pounds of fat daily It should be noted that these data are taken from herds well fed and producing liberally

This does not exclude the possibility that on a roughage ration alone (for example, corn silage and alfalfa hay), some breed characteristic might appear and one breed be able to maintain a higher level of fat production than others on such a ration Some evidence of a breed characteristic has been found in the use of roughage during the growing period of the heifer Data taken by the author show that when rations were used of alfalfa hay alone, or alfalfa hay and corn silage, animals of the Holstein breed ate a larger quantity and made better gains in weight proportion to normal gain

Conclusions The Holstein cow, in common with other large breeds, is a liberal consumer of roughage, exceeding the smaller breeds in total consumed, but this greater use of coarse feed is to be attributed to her greater size An average size Holstein weighs 40 per cent more than the other extreme of the common dairy breeds, the Jersey, and it is not surprising, therefore, that her total roughage consumption is greater According to the feeding practice of both experiment stations and practical breeders, cows of this breed when fed for liberal milk production do not receive any greater proportion of their nutrients in the form of roughage than do the other breeds If there is such a thing as breed characteristic regarding the use of roughage, it is limited to the growing heifer and to the cow in milk when the ration is practically all in the form of roughage and the production, therefore, very limited

Community Breeding While progress has been made in the development of dairy cattle in the United States, the improvement is disappointingly slow The best herds are fully equal or greater in production to the choicest representatives of the breeds in their native homes, the average production of all breeds, however, is below that of the same breeds in the localities in Europe in which they originated Several causes contribute to this end, and among these is the intermingling of breeds in almost every locality in America Although Europe has a large number of breeds—over forty being described on the Continent alone and twelve for Great Britain—the common con-

dition is to find but one breed in a locality. This is a decided contrast to conditions in America, where three or four breeds of cattle may be found within the limits of a small neighborhood. One reason for the much higher average production of dairy cattle in Europe is a better development made possible by this grouping of breeds into localities and by much more rigid culling.

As an outgrowth of this recognition has come a definite policy on the part of those in a position to guide the dairy industry in this country to encourage the development of dairy-cattle breeding communities. A good example is the recent development of the Red Dane breed in Sanilac County, Michigan. When a community takes up such an enterprise, local pride develops and improvement is accelerated. Outside of organized community breeding activities there is clearly a tendency for a natural grouping of breeds by localities as the result of several factors, but this movement advances slowly.

Community preference as a basis for breed selection. The first consideration in the selection of a breed by the beginner should be the breed most generally used in the locality. Instead of selecting a breed because it is not well represented in the community, as is sometimes done under the impression that the demand for surplus stock will be better, it is much wiser to develop a herd of the same breed that already predominates in the locality.

If the dairy cattle development has not reached the point where any community preference has become manifest, the choice will necessarily be made on other grounds. Where a community preference has not been developed, it is often possible for a group of no more than five or six, who will work together for the purpose, definitely to turn the attention of an entire locality to one breed of livestock, to the great benefit of all concerned.

Community organizations. The first organization for the express purpose of developing a community as a breeding center was the Waukesha Guernsey Breeders' Association, organized in 1906 by less than a dozen men of that county in Wisconsin.[3] The possibilities of such an organization were so quickly recognized that others followed rapidly. By 1910, thirty similar organizations were in operation in

[3] Humphrey, Wisconsin Agricultural Experiment Station Bulletin 189 (1906).

Wisconsin This type of community organization spread to other states, particularly Minnesota, but Wisconsin still retains the leadership in this activity Experience has shown these organizations to be successful to the extent that individual members are willing to subordinate their own interests in part to those of the community In the successful communities the spirit of co-operation among the members is striking

Activities of a community organization The primary purpose of such an organization is to promote the welfare of the community by the improvement and development of a certain breed of livestock and the establishment of co-operation and cordial relations between its members that will insure the most successful economic results As a means to this end an association of this kind will be interested in most of the activities listed

1 Increase in number of breeders of the particular breed in the locality
2 Extension of the use of purebred and proved sires
3 Organization of calf clubs among boys and girls
4 Holding public sales for its members
5 Eradication of disease from the locality
6 Establishment of cow testing association and the stimulation of official testing
7 Artificial breeding organizations

During the early stages of a community organization, the objective is securing a large number of breeders of the same class of cattle in the locality and developing the spirit of community co-operation As the quality of the livestock improves, the reputation of the community for high-class animals may be established by suitable advertising in the agricultural press, by the holding of shows and sales, and by other means

Sale of surplus stock One object of a community organization is to facilitate the sale of surplus stock, whether it be grade or purebred When one community has a large number of animals of the same breed for sale, it soon becomes widely known, and a good market for that class of animals is established Buyers are always attracted by the possibility of buying a number of cattle in one neighborhood, and surplus stock can be disposed of much more readily

than where animals are widely scattered. As a result of community breeding, certain localities become known as Holstein centers, others as Jersey or Guernsey localities, and buyers from a distance visit these localities knowing they will be able to find what they want among the large number available.

It is believed that the average price received for surplus animals is fully 20 per cent higher in communities having a reputation which attracts buyers. When the stock in the community is well developed, public sales may be held at regular intervals. However, experience has shown that it is a mistake to hold a sale until sufficient numbers of high-class animals are available. A sale of culls is a detriment to the future development of the community. Likewise the continued unwise sale of the best foundation animals of the community will lead to disaster.

Stimulation for improvement. One of the most important advantages experienced when a community takes up the development of a certain breed is the more rapid advancement made in everything that pertains to cattle breeding and management. This is largely the result of the stimulation as well as the information the individual breeder receives from his association with others interested in the same subjects. Regardless of how much ability or education a person may have, he needs the constant help and counsel of others interested in the same line. When a man is the only breeder of a certain class of livestock in the locality his progress is slower both in knowledge of his business and in building up a reputation which will bring buyers for his surplus. He has no one at hand with whom he can talk over his problems or with whom he can compare results. Often he retrogrades and finally gives up the struggle.

On the other hand, a number of breeders in the same community, especially where a community organization functions, exchange ideas, compare results, and learn from each other's successes and failures.

Exchange of breeding stock. Another of the decided advantages of community breeding is the opportunity it affords to make better use of high-class breeding animals. One of the deplorable facts of present practices in breeding cattle is the limited use made of purebred and tested sires. One reason for this is the feeling on the part of

the farmer that he cannot afford to pay a good price for a bull when the herd is small As a rule the bull has to be sold for beef at the end of two or three years When there are a large number of breeders of the same breed in a locality, it is possible to exchange bulls and by this means to make a more extensive use of high-class animals than would be possible otherwise This also increases the possibility of finding bulls of great transmitting ability before it is too late to make use of them The possibilities offered by the recent development in artificial insemination are just now being recognized Artificial insemination is now in general use in all dairy sections Many hundred thousand cows are now bred each year by artificial insemination

Testing and disease eradication The conduct of official testing has become a necessary part of the business of raising purebred dairy cattle for sale It is generally easier to get official testing done when there is a group in the same locality, especially when these are members of an association If it is desirable to organize a dairy herd testing association to test grade cows, a group accustomed to work together can go ahead to the best advantage The control and eradication of tuberculosis and abortion can also be handled much better where local associations are in existence

Starting the Herd The successful dairy herd, in common with the successful business enterprise of other kinds, usually is started on a small scale and increased as the owner adds to his capital and experience The plan to be followed will depend upon conditions, such as purpose in view, knowledge of the business, and capital available It is seldom advisable for a beginner to take up the breeding of purebred cattle without first having some experience with grades

Assuming that a beginner has already decided what breed he wants, what is the best course to pursue? Should he undertake by using good bulls to build up from common grade cows, or should he buy well bred animals of the breed he has selected, and if so, how should these animals be selected?

A numerous class is represented by a farmer who lives in the corn belt, or the south, or an area where dairying is not well developed or specialized This farmer does not expect to become a dairyman in the sense of making that his exclusive business He expects to operate a

general farm and milk as many cows as one man can handle. He is not certain just how far he will care to go into the business. Probably he has a very limited amount of capital available and there are few well-developed dairy herds near him. He has some cows on hand of mixed breeding with more or less beef blood. A man in this situation should begin milking all cows on hand as they freshen, taking care to have them in good flesh at calving time and making certain that a good ration is fed after freshening. This is giving the cows a chance to make good. The keeping of milk records should begin with each cow as she freshens. Probably half or more of the cows will prove to be such low producers, even when given a chance, that they will not return a profit. These should be sold as soon as conditions are favorable. The keeping of milk and fat records of each cow in the herd should be continued regularly from year to year.

A purebred bull from a family of heavy milking cows should be purchased as soon as it is decided to develop a dairy herd, or the services of an artificial insemination organization arranged for. With most small herds high quality semen from artificial breeding organizations is much more certain and less costly. The heifers only from the best cows should be raised to replace the older cows that are discarded. If the herd has not been tuberculin and abortion tested, it should be tested and started on the way toward a clean and accredited herd.

Herd Building Through Purchase. A somewhat modified plan for a person under the conditions outlined would be to dispose of the stock on hand, if they are not what is wanted, and buy a bunch of bred heifers of the breed chosen. The other details of management remain the same. By starting in this manner with a bunch of well-bred grade females, the time required for getting a start is reduced three or four years. The element of disease is also largely eliminated if such heifers have been tested for tuberculosis and abortion before being purchased. The investment is greater and the owner has to learn the business of feeding and management more quickly, since he will presumably have some cows with good production to deal with almost at once.

Another factor which may decide the practicability of this plan is

the possibility of getting readily in the locality the animals wanted If animals of the breed chosen are numerous locally, so that purchase is easy, the plan of starting with good-grade heifers is to be recommended On the other hand, if no cows of the breed wanted are available locally, it may not be practicable for the farmer to purchase the animals needed from a distance Under these conditions the plan of improvement would be mainly one of using purebred bulls or artificial insemination and culling out the unprofitable cows

As a rule it is wise to purchase as few animals as possible and depend mainly upon raising those needed Not only is there a constant danger of disease when animals are purchased, but when an inexperienced man goes to a distant locality to buy stock he often comes home with a group anything but desirable As a rule the cows offered for sale are the culls, and if really good animals are offered the prices are proportionately high To get a herd of good milkers together by purchase is possible but difficult and expensive As a rule, where all cows are purchased from year to year and none bred, the average for the herd is decidedly lower and shows no indication of improvement.

When buying foundation animals for a grade herd, the best buy usually is bred heifers With animals of this age, the type or appearance offers but a limited basis for judging their probable value About all that can be done is to observe that the animals in question show by their breed characteristics an indication of having a liberal amount of improved blood and that they are well developed for their age and in a good thrifty condition Possibly the most important point to take into account is the quality and production of the herd from which they come, and especially their sire

Often a beginner starts out with the idea of buying only cows with milk records He soon finds it is impracticable to follow this plan, as it is difficult to locate such animals for sale When they are found, the price is high It is better to take the same amount of capital and buy more bred heifers Some of them will prove unsatisfactory and it will be necessary to cull them out, but some extra good ones may also be found

Selling agents located in the districts where whole milk is sold

to cheese factories or condenseries, so that the raising of calves is expensive, often make a business of shipping heifer calves. The calves are shipped at the age of two to four weeks and are generally guaranteed to be sired by purebred bulls. Farmers needing to add to their herds for the future, especially in cream-selling districts where skim milk is available, find it profitable to buy calves under these conditions.

Herd Building. In every dairy herd, purebred or grade, will be found certain cows that are superior producers, good feeders, and good breeders, and keep free from disease. These are the foundation cows from which heifer selection should be made. The importance of "cow families" has never been fully appreciated by American dairymen.

Guarding Against Disease. The problem of keeping a herd free from diseases such as tuberculosis, contagious abortion, and mastitis is always a difficult problem. To the beginner it is a particularly important problem since these diseases, once introduced, are difficult to eradicate. If a herd is started with clean animals, and additions to the herd by purchase are kept to the minimum, it may be possible to maintain a healthy herd for years. Once a herd is free from disease, it is wise to limit the purchase of animals to the necessary bulls. Many breeders have learned by bitter experience that if the practice of adding to the herd from time to time purchase is followed, sooner or later disease will gain a foothold, even though every possible precaution has been taken.

Tuberculosis. Tuberculosis is discussed later, so that it is the purpose here to consider only the question of starting and maintaining a herd free from this serious disease. Tuberculosis does not develop spontaneously. It spreads only by the transmission by an infected animal. An animal may have a bad case without showing any outside symptoms whatever. The placing of such an animal in a healthy herd may result in the greater part of the herd contracting the disease within a few months. When animals are bought, especially for starting a herd, every animal should be given the tuberculin test by a competent veterinarian, or be bought only from accredited herds.

A cow in the advanced stages of the disease, and acting as a

spreader, sometimes shows by her physical condition that something is wrong While it should be understood that all spreaders do not show what they are by their physical condition—nor are all unthrifty animals infected with tuberculosis—still it is wise to be on the safe side and to reject from the herd any animal that becomes emaciated or shows a decidedly unthrifty appearance which cannot be overcome by good feed

Abortion or Bang's disease This insidious disease now outranks tuberculosis in importance to the dairy cattle industry From a purely financial standpoint the loss is much greater This disease has been especially widespread in sections where there has been considerable buying and selling of cattle In some sections infection runs as high as 25 to 30 per cent in the larger dairy herds Fortunately very reliable rapid blood tests have been developed, as well as reliable vaccines such as Strain 19 Under the present plan of area herd testing, the elimination of all reactors, and the use of calfhood vaccination, this disease is being brought under control equally as effective as the present control of tuberculosis

It is a well known characteristic of the disease to go in waves in a herd For a period, usually a few months, it is very active, at times half the cows losing their calves, then it gradually recedes While in this stage the owner often ascribes to accidents the few cases which occur However, a cow very seldom aborts from accidents, and so long as any cases of abortion occur, the presence of the disease is probable After a dormant period the disease flares up again as before —to be again followed in a few months by a dormant period The importance of understanding these facts is to avoid overconfidence in assuming that because very few or no abortions have occurred for a number of months the disease is gone If it was once dormant, it is probably merely dormant again, only to break out later with increased virulence The safe thing is to follow a regular testing and control plan

The indications are that the open heifer seldom carries the infection If her first calf is aborted she probably became infected during the gestation period This suggests that the danger of introducing the germ of the disease with purchased animals is reduced if heifer

calves or unbred heifers are introduced rather than older animals. Animals once infected seldom become negative later, although such statements are frequently made by those who oppose the test. Constant and consistent blood testing coupled with stringent isolation at calving and disposal of all reactors have proved the most successful methods in controlling this disease, which is more fully discussed under diseases of cattle in Chapter XXIV.

Mastitis. This disease is more commonly known as caked udder or garget. It is caused by a variety of conditions. Among them may be mentioned bruises of the udder, exposure to cold, irregular milking, and most common, the infection of the udder tissues by specific organisms. The disease is very prevalent in all dairy sections of the country. It is a costly disease because of the loss of milk in infected cows, the loss of one or more quarters, and the final loss to the herd of diseased cows. It is one of the most common causes of the removal of milking cows from dairy herds A more extended discussion of this disease may be found in Chapter XXIV.

Trichomoniosis, Vibrio Foetus, Leptospirosis. These are other recently recognized infectious diseases which are becoming troublesome in our American dairy herds They are more fully described in Chapter XXIV.

CHAPTER XII

Selection of the Individual Cow

Necessity for Selection Breeds are of great value as a means of preserving and transmitting qualities which have already been developed, and it is highly important to select a breed adapted to the purpose for which it is to be used However, the selection of the individual cow within the breed is of even more importance as affecting the economic production of milk

The highly developed dairy cow of today is, to a large extent, highly abnormal It is safe to assume that the wild cow produced only milk enough to support the calf for a few weeks until it could subsist on other food There was probably little difference in the amount of milk produced by different individuals at this time, and the milking characteristic was undoubtedly transmitted rather uniformly

After cattle were in a state of domestication and the milk became an important article of human food, some attention began to be paid to developing the milking functions Through natural variations, certain animals showed more highly developed milk producing functions than others, and by using these animals for breeding purposes and rejecting the low producers, a change was gradually made in the amount of milk secreted, and probably to some extent in the quality as well While the wild cow possibly produced from one to two thousand pounds of milk in a year, a good dairy cow of today may produce more than this in a single month

Specialized characteristics It is a well known fact, and one easy to understand, that, when any characteristic or function has been

developed to a higher degree than is normal or average for the breed as a whole, this abnormal trait or characteristic may not be transmitted as uniformly as desired. Although there is much argument by practical animal breeders, there is no evidence that such specialized characteristics may be acquired and be bred on in future matings. There is a constant tendency for the characteristics of some of the ancestors to appear. This is called reversion to type. This explains why there is such a wide variation in the capacity of individual cows to produce milk. Scientists tell us that this phenomenon happens less frequently as the new or specialized charactertistic becomes established in the breed, but it can be of considerable importance to the cattle breeder, who must always keep this possibility in mind in his selection of his breeding animals.

Significance of Individual Variation. While conditions differ with a family cow, with cows on general farms, and with specialized dairy herds where a large amount of capital is invested, it is only within recent years that the full significance of individual variation has been understood. One of the weakest points in the system of dairy farming as carried on at the present time is the failure on the part of a large number to appreciate the importance of this factor of individual selection, or, if it is appreciated, a failure to give this subject the attention and time which its importance justifies. Even when cows are milked regularly and the selling of dairy products is a regular business, the yearly butter production seldom exceeds 300 pounds per cow except in the hands of the special dairyman, and this allows but little or no profit under present costs of production.

Variation in Production by Individuals. Credit for first calling attention to the great importance of the selection of the individual cow is due the Illinois Experiment Station.[1] Beginning in 1902, eighteen herds numbering 221 cows were tested through complete milking periods. A summary of the results is given in Table 12. The average milk production was 5,617 pounds and the fat production 227 pounds. The best herd averaged 350 pounds, the poorest 142 pounds, of butterfat per cow. The best ten cows averaged 389 pounds, the poorest ten 142 pounds, of butterfat per cow for the year. Herds

[1] Hopper, Illinois Agricultural Experiment Station Circular 102 (1906)

which had been graded up by the use of a purebred sire produced 85 pounds of butterfat more per cow than did those in which no grading had been done These herds were in the hands of men who were making the production of milk their principal business As a result of the investigation it was concluded that at least one third of the cows in ordinary herds which were being used for milk production in that state were unprofitable, and that on nearly every dairy farm a few cows were kept at an excellent profit, some at a small profit, and some at an actual loss

Table 12 Production of Average, Best, and Poorest Cow in Twenty four Illinois Herds

Herd	No Cows in Herd	Lbs Milk			Per Cent Fat Lbs			Butterfat		
		Average	Best	Poorest	Average	Best	Poorest	Average	Best	Poorest
1	11	5 753	6 099	4 391	4 54	5 17	3 91	262	315	172
2	8	376	8 739	4 928	3 19	3 81	3 92	268	333	193
3	5	8 057	9 454	6 719	3 42	3 40	3 27	276	324	221
4	11	6 270	7 445	4 091	3 89	4 82	3 83	242	359	157
6	20	7 873	9 067	5 796	3 62	4 41	3 65	285	399	212
7	10	4 525	5 507	3 412	3 76	4 70	3 78	170	264	129
8	10	4 486	6 647	2 691	4 29	3 09	3 61	193	263	97
10	13	5 431	7,291	3 847	4 18	4 31	4 38	227	315	168
11	9	5 969	6 531	5 552	3 43	3 78	3 01	205	247	168
12	13	4 504	6 429	2 090	3 89	3 80	4 83	175	248	101
15	12	5 178	6 289	3 491	4 03	4 74	3 01	207	299	135
16	9	4 608	5,293	3 752	3 98	4 49	3 99	184	238	150
17	7	4,355	6 115	3 710	3 96	3 31	3 33	173	203	124
19	19	5 410	6 413	4 530	4 11	4 57	3 49	243	293	158
20	15	6 106	7 530	2 980	3 84	3 93	4 56	235	296	136
21	15	5 9 1	8 882	4 025	4 06	3 75	3 55	243	333	143
23	25	3 314	4 33	1 846	4 78	4 96	4 24	142	216	78
24	9	5 921	6 911	3 478	5 91	6 91	4 64	350	477	161
	221	5 616	6 994	3 962	4 03	4 55	3 83	226	301	150

A large amount of data which corroborate these early conclusions has been accumulated, largely from the records of cow-testing associations, since the pioneer work reported in Table 12 was published by the Illinois Experiment Station A study of the same question has been made from data taken from the Michigan D H I A [2] reports

[2] Washtenaw County Dairy Herd Improvement Association Report for 1944

which are shown in Table 13. These data show the same wide variation in the cost of production by individual cows as that found in the investigations previously noted. In this case the best cow produced butter at feed cost of 27.0 cents per pound as compared with 30.0 for the least profitable. The best cow consumed feed worth \$3.40 for each \$1 expended for feed for the poorest, but at the same time she gave a return of \$4.51 for each \$1 spent for feed for the inferior animal.

This table shows that the best cow produced about four times as much as the poorest cow. The former gave a return of \$3.23 for each dollar invested in feed to \$2.70 for the latter.

Table 13. Results Taken from the Dairy Herd Improvement Association Records of Washtenaw County in Michigan, 1944

	BEST COW IN ONE HERD	POOREST COW IN ONE HERD
Milk produced (pounds)	9316	2236
Butterfat produced (pounds)	514 9	136 0
Total value of products	\$449 66	\$111 00
Cost of feed per cow	139 15	41 15
Value of product over the cost of feed	310 51	69 85
Feed cost of 1 lb. of fat in cents	27	30
Returns for each \$1 invested in feed	3 23	2 70
Profit on each \$1 invested in feed	2 23	1.70

The following figures are taken from a report of a Dairy Herd Improvement Association in Gratiot County, Michigan, for 1947.

	FEED COST	VALUE OVER COST OF FEED
Average of 26 herds	\$122	\$236
Average of 3 high herds	\$150	\$277
Average of 3 low herds	\$100	\$202

Average yield was 8,252 pounds of milk, 341 pounds butterfat for 26 herds, year, 1947.

Vast quantities of data could be assembled, all showing the same facts. The extremes in production indicated by the data given are not

confined to any breed or geographical location. While in purebred or highly developed grade herds the proportion of inferior producers is less than in herds of more common breeding, still a certain proportion of unprofitable cows may be expected even in herds of this kind. It is no reflection upon a breeder to have such animals appear occasionally, but it is a reflection upon his judgment if he retains them in his herd.

The Economy of High Production. The amount of milk and fat produced bears a direct relation to the economy of production. This fact can be shown by any amount of data. Those given in Table 13 are typical. The best cow consumed feed worth $98.00 in excess of the poorest animal, but produced 379 pounds more fat.

The most abundant evidence on this point is furnished by the records of 120 co-operative cow-testing associations. The cows are grouped in classes according to the amount of fat produced in a year, and the gain shown for each group is the average net gain over cost of feed per cow. Groups with insignificant numbers have been omitted from this table.

Table 14. Relation of Fat Production to Income over Cost of Feed. A Summary of D.H.I.A. Records*

NUMBER COWS	AVERAGE MILK PRODUCED (POUNDS)	AVERAGE BUTTERFAT (POUNDS)	PRICE OF PRODUCT	TOTAL COST OF FEED	VALUE OF PRODUCT OVER FEED COST
36	3894	154	$0.95	$101	$45
131	5102	206	89	105	78
337	6109	252	89	110	113
484	7204	301	89	123	144
Median					
561	8322	349	89	130	180
417	9505	398	90	139	219
258	10453	447	88	147	247
129	12172	496	90	157	291
50	12614	546	87	166	310
23	14058	596	88	169	356

* U.S.D.A. *Dairy Herd Improvement Association Report*, 1946.

The following table shows the results of a survey of the cost of milk production in Jefferson County, New York.[3]

Table 15. Relation of Milk Production to Income Above Feed, Jefferson County, New York

AVERAGE LBS. YEARLY MILK PRODUCTION	NUMBER COWS	PROFITS PER COW OVER FEED COSTS
5,000 or less	159	$ 6 04
5,001 to 7,000	360	16 69
7,001 to 9,000	214	27 21
9,001 to 11,000	84	39 39
Over 11,000	17	75 53

This survey embraced 53 herds numbering 834 cows, the average production being 6,621 pounds milk and 241 pounds fat; 19 per cent of them caused their owners a loss of $11.18 each.

Relation of Production to Nutrients Required. As a further illustration of the advantages of keeping good cows, the following figures are shown as the result of milk production in three counties in New York State.[4]

Table 16. Relation of Milk Yield to Nutrients Required

AVERAGE LBS. YEARLY MILK YIELD	NUMBER COWS IN GROUP	TOTAL DIGESTIBLE NUTRIENTS PER 100 LBS OF MILK
5,000 or less	335	58 5
5,001 to 7,000	368	47 1
7,001 to 9,000	112	42 6
Over 9,000	32	40 0

As the production increased, the total digestible nutrients per hundred pounds of milk showed a decided decrease.

Extensive figures were gathered in Wisconsin some years ago during a dairy cow competition (see Table 17).[5] The cows are listed in groups of thirty, according to production.

[3] Hopper and Robertson, Cornell University Experiment Station Bulletin 357 (1912)
[4] Thompson, Cornell University Agricultural Experiment Station Bulletin 364 (1915)
[5] Woll, Wisconsin Agricultural Experiment Station Research Bulletin 26 (1912)

Table 17 Results from the Wisconsin Dairy Cow Competition

GROUPS OF 30 COWS	AVERAGE LBS BUTTERFAT	VALUE OF PRODUCT	COST OF FEED	NET RETURN
1	673 9	$217 26	$102 71	$114 55
2	568 9	182 86	91 40	91 46
3	528 9	170 99	86 49	84 50
4	493 8	158 78	84 74	74 04
5	472 4	150 60	81 87	68 73
6	455 6	145 24	75 69	69 55
7	438 3	139 38	71 72	67 66
8	421 0	134 43	70 96	63 47
9	399 3	126 28	72 47	53 81
10	375 0	117 91	72 13	45 78
11	355 1	110 98	60 8	50 20
12	326 9	102 41	57 66	44 75
13	274 9	86 29	56 56	29 73

Relation of Individual Production to Costs A careful study of the cost of producing milk on four dairy farms located in Wisconsin, Michigan, Pennsylvania, and North Carolina brought out the same truth regarding the relation of the individual cow to the cost of production Table 18 gives the results

Table 18 Relation of Production to Feed Cost and Income Results from Wisconsin, Michigan Pennsylvania, and North Carolina

PRODUCTION OF MILK PER COW LBS	NO COWS	AVERAGE PRODUCTION LBS	AVERAGE PER COW PER YEAR			AVERAGE PER 100 LBS MILK	
			Feed Cost	Other Cost	Total Cost	Feed Cost	Total Cost
3 000 and under	16	2 349	$43 93	$39 97	$83 90	$1 87	$3 57
3,001 to 4 000	33	3 648	49 4	45 01	94 48	1 36	2 50
4,001 to 5 000	78	4 596	55 00	50 04	105 04	1 20	2 29
5,001 to 6 000	111	5 450	59 91	54 51	114 42	1 10	2 10
6 001 to 7 000	109	6 443	62 85	57 18	120 03	93	1 86
7,001 to 8 000	60	7 513	0 38	64 04	134 42	94	1 79
8,001 and over	36	9 049	80 45	73 20	153 65	89	1 70

It will be noticed that as milk yield increases, there is also an increase in the feed cost and *in other cost items, but in the same* proportion The decrease in cost of producing one hundred pounds of milk is much greater between the very poor cow and cow of

medium quality than it is between the medium cow and the good cow. Because of this fact, the most rapid herd improvement will follow *the elimination of the poorest cows*. The *rapid rise in recognition* of the Red Danish Cattle as the most efficient dairy cows in Europe today is largely due to consistent and universal practice by Danish dairy farmers of rigid elimination of all low producers.

A study of the yearly records of 18,014 cows kept by cow test associations is summed up by McDowell as follows:

"Cows having high average production of milk and butterfat averaged high in income above feed regardless of breed, age, weight, date of freshening, or geographical location. Cows having an average milk production of 3,250 pounds had an average income of $32.50 over cost of feed, while those having an average milk production of 13,250 pounds had an average income of $218.19 over cost of feed. The average production per cow in the latter group was about four times as great and the average income over cost of feed was nearly seven times as great as in the other group."

The general conclusion can be drawn from the data given that it only costs from $5 to $30 more per year to feed a cow (depending upon the price of feeds) that will produce 300 to 400 pounds of fat than it does to feed a cow producing from 100 to 200 pounds of fat.

Herd Numbers and Herd Profit. The farmer too often makes the mistake of thinking that a certain number of cows should give a certain amount of product, and that the sum received from his herd should be comparable with that received from another herd of the same size. The point is overlooked that it is not quantity, either of milk produced or number of animals kept, that determines the profit, but the income in excess of the cost of production. In any herd of 15 to 20 cows that has not been carefully culled, a greater total profit will be realized by retaining from half to two thirds of the herd and disposing of the inferior ones. This is especially true of herds composed of common grade and dual-purpose animals.

One cow producing 300 pounds of fat in a year makes vastly more profit than do two cows producing 150 pounds each, although the total production is the same in each case. The reason can be easily understood when we consider the use which the animal makes of its

feed The first use to which the cow puts the feed given her, as is the case with any animal is to maintain the body, which in this case is keeping up the machinery for milk production The feed necessary for this purpose is called the ration of maintenance With an ordinary cow producing 200 pounds of fat in a year, the ration of maintenance represents from 50 to 60 per cent of the feed she consumes, in the case of a better producing cow, about 40 to 50 per cent of her ration, while an extraordinary producing cow may not use over 35 per cent of her ration for this purpose This may be looked upon as a fixed charge which has to be made in the case of every animal, and since in any except especially good producing herds, at least half of the feed will be used for this purpose, it is clear that keeping two cows to do the work of one is increasing the total amount of feed used by something like 25 per cent

Cause of Individual Variation It has been the purpose of this chapter to emphasize the selection of the cow from the standpoint of her milk-producing capacity The assumption has been in this discussion that the low production figures are due to a limited capacity of the cow to produce milk, in other words, that all have had a fair chance As a matter of fact, low production under farm conditions is the result of poor feeding as frequently as of inferior animals The figures used, however, in most cases are not comparisons between herds but within herds, and by this means the result of variation in feeding is largely eliminated

Limiting the discussion from this point on to the cause of the variation in capacity of the cow to produce leads to a consideration of milk secretion

Inherited Variation in Milk Secretion. The cow that is a superior milk producer for her breed has received something by inheritance differing in degree from that inherited by the inferior milk producer Without this internal factor, this stimulation from the inside, the best of feed and care will not yield results Just what this internal factor may be is a physiological question too difficult and involved to be discussed here except in a brief statement. According to physiologists, the udder glands which secrete milk are stimulated into activity as the result of the secretion of other glands, belonging to

that group known as *ductless* or *endocrine glands* *The stimulating* substance is secreted by the anterior lobe of the pituitary and is carried through the blood. This substance, the hormone known as prolactin, stimulates the udder gland to produce milk. The amount of this substance that a certain animal secretes depends upon the

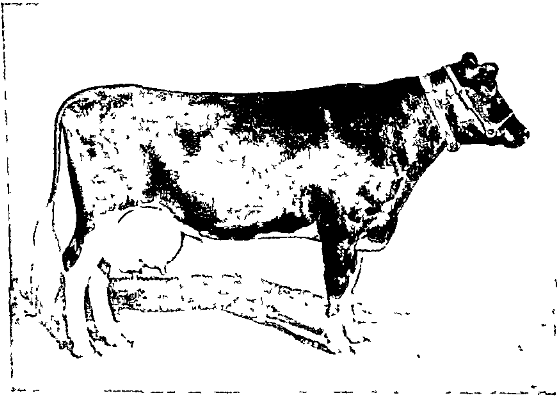

FIG. 27. Purebred Holstein cow This cow had good ancestors, was healthy, but lacked the inherited stimulation for satisfactory production

development and vigor of the gland by which it is manufactured. A good dairy cow is one that has inherited the power to form a large amount of this substance, while an inferior animal is one with a weak stimulation to produce milk. From this viewpoint the selection of the cow is choosing the one that has a strong inherited stimulation to produce milk.

Inherited stimulation may be strong. An experiment made by the author illustrates how strong this stimulation may be. A mature Jersey cow was fed a liberal ration while dry; she calved in more than moderate flesh. Her ration was then adjusted to supply only nutrients sufficient to support the body, leaving nothing for producing milk.

She was compelled either to cease producing milk or to make it from the reserve on her body This was continued for 30 days At the end of this time she was producing only one pound of milk per day less than in the beginning, but was so weak she could hardly get up without assistance During this time she lost 115 pounds in body weight and produced over 90 pounds of solids in the milk taken from her own body.

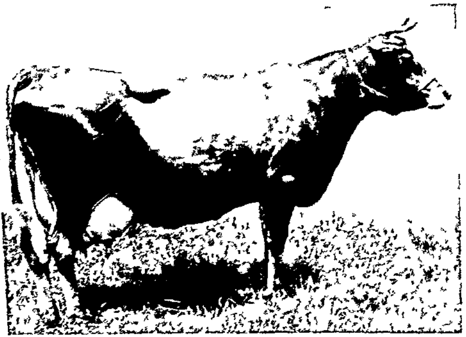

FIG. 28 Duke's Rachel Interested This purebred Jersey cow made five remarkable yearly records *Inherited characters for high production made this production possible*

According to the view expressed, the high-producing cow secretes milk on account of the strong stimulation she has in her body To replace these nutrients she has a keen appetite and consumes a large *amount of food The point is this she consumes the heavy ration because she produces a large amount of milk* The consumption of the heavy ration is the result and not the cause of the heavy milk production, and likewise the form or shape of the animal is influenced to a degree. Her *inherited stimulus to produce large quantities of milk*

demands that she consume ample feed, which tends to develop the organs of digestion. Similarly, the generous secretion of milk develops the mammary system. The result is the close approach to the ideal dairy form. This subject is further discussed in connection with feeding, to which it bears an important relation.

Reason for Economy of High Production. It seems entirely reasonable that a cow producing a large quantity of milk should be a more economical producer than one with a small capacity. However, careful thought is required to understand the reason properly. The assumption is often made that the good dairy cow in some way is able to get more out of feed than an inferior cow, but digestion trials do not bear out this view. The portion of a given ration that is digested and used is practically the same for all individuals, regardless of milk-producing ability, age, or breed.

The real explanation of the economy of production by the higher producer may be illustrated to advantage by reference to results obtained by the author in a study of this subject. The two cows used were registered Jerseys and daughters of the same sire. The striking difference in their milking ability attracted attention. The good producer is designated as No. 27 and her inferior half-sister as No. 62. The cows were about the same age and were raised in the usual manner on a typical skim milk ration. During the first two years in milk under the same conditions and with equal opportunities the results were as follows:

	AVERAGE LBS. MILK PER YEAR	AVERAGE LBS. FAT PER YEAR
No. 27	5,863	308
No. 62	2,003	79

These striking results attracted attention and plans were made to find the explanation. The two cows were bred so that they calved one week apart, and they were then kept under the following conditions:

1. Complete record kept of amount and composition of feeds consumed
2. Ration fed the two cows of the same composition at all times, the amount varied to suit the individual.

3 Cows kept at uniform weight
4 Complete records made of milk produced and of its composition
5 Cows kept farrow
6 Digestion trial conducted when the cows were at their maximum production
7 Cows kept on maintenance for four months at the end of the milking period to determine maintenance Maintenance ration of same com position as that fed when producing milk to determine maintenance in terms of the ration fed

During the year, No 27, the better cow, produced 8,522 pounds of milk and 469 pounds of fat, while No 62, the inferior cow, produced only 3,188 pounds of milk and 169 pounds of fat, although (1) the maintenance requirement was practically the same for each, and (2) the coefficient of digestion was almost exactly the same

Table 19 gives the feed consumed during the year, the amount of feed required for maintenance, and the amount available for milk production by the two cows

Table 19 Feed Consumed Maintenance Requirement and Amount Used for Milk Cows Nos 27 and 62

	LBS GRAIN	LBS HAY	LBS SILAGE	LBS GREEN FEED
No 27				
Consumed during year in milk	3 424	2 904	8,778	4 325
Maintenance for year	1 201	1 205	4 818	
Available for milk production	2 223	1 699	3 960	4 325
No 62				
Consumed during year in milk	1 907	1 698	5 088	2 102
Maintenance for year	1 066	1 066	4 293	
Available for milk production	841	632	795	2,102

It will be noted that the feed available for producing milk is much larger for No 27 than for No 62 During the year in which these rations were fed, No 27 produced 2 77 pounds of fat to each pound produced by No 62 During the same period No 27 had 2 64 pounds of feed available for milk production to each pound available by No 62 This means that after the ration of maintenance was supplied, practically the same amount of food was required by each for making

a pound of fat. The real difference between the two cows was that with No. 62 the stimulation for secreting milk was limited to about one third that possessed by No. 27. No. 27, due to this strong stimulation, produced nearly three times as much milk as No. 62, and as a result required more feed. No. 27 was a more efficient milk-producing machine on account of greater capacity to use food above maintenance. The food she consumed was not used to any better advantage than that eaten by the inferior cow. No. 62 required 55.8 per cent of her ration for maintenance, and No. 27 only 35 per cent.

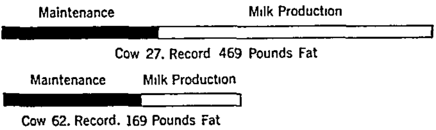

FIG. 29. This graph illustrates the use of feed by No. 27 and No. 62. The amount used for maintenance was about the same for both. In addition, No. 27, on account of her greater internal stimulation to produce milk, used 2.6 times as much feed for milk production as No 62. The higher producer uses more feed, but is the more economical because of the smaller overhead in the form of maintenance.

The problem is illustrated graphically by Fig. 29. From the farmer's standpoint No. 27 was a very profitable cow, while No. 62 did not pay for her feed. The difference between these two cows in regard to the use of food clearly was the amount used above that necessary to maintain themselves. *This experiment shows that the main difference between profitable and unprofitable dairy cows is not to be found in the coefficient of digestion or in the food required for maintenance.* A superior dairy cow is one with a large capacity for using food above that maintenance requirement, and one that uses this available food for milk production.

Other Economics of High Production. It should be kept in mind that the feed cost is approximately half the total expense of milk production. Table 18 supplies data on this point. The other expenses include labor, barn expense, taxes, depreciation in value, bull service, and veterinary fees and possibly others of minor value. These over-

head expenses, like those of feed, increase somewhat as the level of production is raised, but not at all in proportion In Table 18 it will be noted that the other costs for cows producing 3,000 to 4,000 pounds yearly was $45 01 a year or $1 28 a hundred for the milk For cows producing 7,000 to 8,000 the costs other than feed were $64 04 a year or 85 cents a hundred The high-producing cow, as pointed out, uses more feed than the cow producing at a lower level, and the same is true for the overhead expenses other than feed But the important point is that this increase is not in proportion to the increase in milk produced, and that the great economy of high production results from a combination of this saving in feed and in general overhead expenses

CHAPTER XIII

Selection of the Cow by Records

METHODS OF SELECTION

The selection of the individual cow has to be made either by judging the dairy qualities of the animal from her conformation or from records of her milk and fat production. There is no doubt that in most cases the high-producing dairy cow shows what is generally recognized as the dairy type. Competent judges can readily select very good cows from inferior ones by observing the extent to which they approach a recognized dairy type. However, dairy type alone cannot be depended upon as a means of selecting the best dairy animals from among a number of good ones. As a rule, it is possible to select cows that are capable of producing from 300 to 350 pounds of fat in a year from those that will produce half that amount; but it is practically impossible to select a cow capable of producing 400 to 500 pounds of fat from one producing 300 pounds of fat. Often those persons most familiar with the subject will make decided errors in selecting animals by this means.

Limits of Selection by Type. One of the special difficulties in selecting animals by type is that the conditions under which the selection is made are often very unfavorable. In the show ring the cows exhibited in the mature classes are nearly always in milk, and all are well fed and in good physical condition. On the other hand, when one farmer is buying from another, the conditions are far less favorable for comparing the animals. Some are fresh, others dry or nearly so. Some may be in good condition; others, on account of poor feeding,

thin in flesh and unthrifty Few judges of dairy cattle would recognize as superior animals many of the great record cows of the various breeds if they were dry and in a herd of any considerable size, the majority of which were in poor condition

Selection by type, however, has its value, even in dealing with grade cows kept for commercial production alone, since it is generally the only practicable basis for buying such animals Records of production are available for only a limited number of cows, and those which have demonstrated their worth are not generally for sale In case an animal is to be purchased for which no records of production have been kept, the buyer must depend mainly upon the evidences of dairy characteristics as shown by the animal, and it will be well to depend upon these rather than to attempt to select by weighing and testing the milk for a single milking, or even for an entire day As a rule, in such a case the conformation of the animals should be depended upon as an indication of dairy quality rather than statements regarding the production of the animal, unless such statements are based upon actual weights and tests taken

Selection by Records When cows are to be purchased, it is generally necessary, as suggested, to depend to some extent upon the indications of dairy qualities as shown by the type of the animal In the management of a herd the conditions are different, and there is no reason for basing upon their dairy type the selection of the individuals to be retained in the herd The only satisfactory way to select the profitable from the unprofitable in a herd of dairy cows is by keeping records of the amount of milk produced and then testing for butterfat at regular intervals There is no excuse for not keeping records because the unprofitable cows should be detected and rejected from the herd as soon as possible

The records to be taken should include the total milk production based upon the weighing of each milking, and the fat production calculated from the average fat percentage in the milk and the total milk When the milk is sold by weight alone, the producer is interested mainly in the milk yield, but it is wise even under these conditions to keep the fat records as well In keeping records, or in making use of the records in buying or selling cattle care must be taken to give

proper weight to milk yield and to the fat content. As shown by the next paragraph, it is a serious mistake to judge an animal by either of these alone.

Overrating the Importance of Rich Milk. A common mistake in the judging of the value of cows is that of attaching undue importance to the richness of the milk. The cow that gives the richest milk does not necessarily produce the largest quality and is not necessarily any better than, or even as profitable as, the cow yielding milk with a smaller per cent of fat. It is the total fat production rather than the fat percentage that counts. The fallacy of depending upon the percentage of fat in the milk as an index of the value of an animal is especially dangerous when animals of different breeds are involved. The figures given below are the average of the records of a group of each breed represented, made under the supervision of the author:

	LBS. MILK	PER CENT FAT	LBS FAT
Jersey	6,749	5 01	338
Holstein	10,911	3 5	382
Guernsey	6,971	4 96	346

It is clear from these figures that neither the milk nor the fat yield alone offers a fair basis to judge between the breeds. Judging by the fat percentage alone, the Jersey and Guernsey are far superior; while *if the milk yield is made the basis of judgment, the Holstein is far in* the lead. The same condition exists within the breed. A herd of any breed should not be culled upon the basis of the test alone, nor should either high or low test be overemphasized when buying or selling without taking the milk yield into account as well.

Breed Variation in Milk Yield and Richness. Within a breed there is no apparent relation between the milk yield and the richness of the milk. This truth is somewhat contrary to popular opinion, which is that a high milk production goes with a low test and low milk production with a high test. Figures in Table 20 were assembled from records of a herd under the author's supervision.

These figures show that there is little of any relation between the yield of milk and the test. A high milk yield may be accompanied by

either a low, a medium, or a high fat content, and the same may be said of a low milk yield The test of the milk bears little relation to the total fat yield There is, however, a very close relation within the breed between the milk yield and the fat yield The striking fact brought out by this table is that the milk yield varies far more widely than does the fat percentage

Table 20 Relation of Percentage of Fat to Milk Yield and to Total Fat Production

BREED	HERD NO	LBS MILK YIELD PER YEAR	LBS TOTAL FAT YIELD	AVERAGE PER CENT FAT
Jersey	1	13 895	681	4 90
Jersey	16	12 729	634	4 98
Jersey	124	13 327	625	4 69
Jersey	67	3 188	169	5 31
Jersey	5	2 797	176	6 20
Jersey	45	2 849	176	4 60
Holstein	204	18 405	618	3 41
Holstein	211	17 697	519	2 93
Holstein	214	5 436	212	3 92
Holstein	205	6 387	708	3 20
Guernsey	502	13 878	606	4 37
Guernsey	G-4	3 388	146	4 30
Guernsey	G-6	2 307	134	5 80
Guernsey	517	12 188	672	5 10

In the figures given, one Jersey produced more than five times as much milk as another and the result is not unusual with any breed It might be possible to find one cow that would show an average fat content one half higher than another in the same breed, but even such extremes are exceptional In a herd where different breeds are represented, the variation in fat percentage may be somewhat wider

The Importance of the Milk Yield. The foregoing discussion shows that the variation between individual cows is from three to five times as great in milk yield as in fat percentage, and that the milk yield bears a very close relation to the total fat production These facts make it clear that the most important part of records is the weight of the milk. In starting to keep records, provision should always be made first for keeping these weights It is at least three times as important

to weigh the milk as to test it, although both should be done. The man who attempts to cull his herd on the basis of a few butterfat tests made from the milk of each cow will certainly do his animals injustice in many cases. In fact, culling on such a basis is worse than useless. The advice often given "to go after your cows with a Babcock test" is not sound. The test is needed, but the first and most important thing is to keep the record of milk produced. This should be accompanied by systematic testing for fat with the Babcock test.

In communities where milk is sold to factories on the butterfat basis, certain herds are often considered the best in the community simply because *the percentage of fat from these herds is the highest;* but this should not be taken as evidence that they are the most profitable herds.

The Three Factors in Individual Selection. There are three things that should be known in order that the relative profits may be ascertained from the individual animals. These are: the amount of milk produced, the percentage of fat, and the cost of feed consumed. In regard to recording the feed cost of each animal, the view of the author is that it is not practicable on the farm, because of the time required. It is wise, however, to keep sufficient records to determine if the herd as a whole is profitable. It is well established that within the herd the profits are in direct proportion to the production of the animals.

KEEPING MILK RECORDS

Testing at Monthly Intervals. The plan in general use consists in weighing the milk for a period of from one to three days, once a month, and testing a sample representing the same interval for butterfat. In carrying out this method, the best arrangement is to weigh the milk from each individual cow for three days about the middle of the month. A composite or average sample of the milk is also taken during the same time, which is tested for per cent of fat. The average milk and fat produced for the period is taken as the average for that month. This should be carried out regularly each month during the year. The total production of each cow as shown by such tests is close enough to the actual for all practical purposes. One disadvantage of

Records detect sickness The third advantage in having daily records is the opportunity it affords the herdsman to detect sickness in a particular animal before it would otherwise be observed If there is a noticeable decline in the amount of milk produced, with no apparent cause, it is certain the animal is not in the right condition and will probably show a more marked case of sickness very soon, if not properly treated When such a sudden decline occurs, the herdsman, by adjusting the ration and giving the cow some special attention, will be able in many cases to prevent the development of what might otherwise be a serious case of sickness

Records reveal competence of milkers A fourth reason for weighing and recording each milking regularly is the chance it gives to judge of the work of different milkers It is a well known fact that some milkers are able to secure much more milk from the same cows than are others The difference may be as much as 25 per cent, or even more Especially where there are several milkers in the same herd, it is impossible to form a fair estimate of their work unless each man milks the same animals regularly, and each lot of milk is weighed and recorded

Record keeping adds interest to work A fifth and very important purpose in keeping records is the interest the practice adds to a task that is at best more or less monotonous When each milking is recorded, the milkers will observe the variations from day to day and find many things of interest in tracing the cause A friendly spirit of competition is often developed which also leads to more interest in the work and consequently, better results

Method of Taking and Testing Samples Where many samples for testing are to be taken the most convenient and accurate method is with a sampling tube, which can be purchased from a dairy supply company In taking a sample with this apparatus, the sampler, which is a brass or copper tube, is lowered in the pail of milk and then closed The milk remaining in the tube is placed in a pint glass jar bearing the name or number of the cow These jars must be kept covered tightly to prevent evaporation If a sampling tube is not at hand a satisfactory sample may be prepared by taking equal quantities of the milk from each milking with a very small dipper after

thoroughly mixing them by pouring from one pail to another. A screw-top jar, properly labeled, should be provided for each cow to be tested. Some preservative is used to prevent the souring of the milk before the time for testing. For this purpose formalin, which may be purchased from any drug store, is one of the best agents. Ten drops of this substance will be sufficient to preserve half a pint of milk for several days. A small amount of corrosive sublimate (bichloride of mercury) serves the same purpose and is at present most commonly used. This substance is a strong poison, and for this reason milk containing it must be handled very carefully. If corrosive sublimate is used it is wise to use it in the form of prepared tablets containing a coloring matter, or to add some common dye to prevent the milk from being used for food by mistake. The samples when complete are to be tested by the Babcock test.

Calculating the Fat Yield. The reading of the Babcock test is in terms of butterfat percentage or pounds of pure fat per 100 pounds of milk. The total yield of milk multiplied by the per cent of fat gives the total fat yield. If the cream from this milk should be separated and churned into butter, a yield of butter would be obtained in excess of the butterfat. This results from the incorporation of some curd, considerable water, and a small amount of salt with the fat, the mixture being ordinary butter. If proper methods are followed, the yield of butter will exceed that of the fat in the milk by about one sixth. This excess of butter over butterfat is known as "overrun." The overrun in a skillfully operated creamery should be 20 to 22 per cent, based upon the fat as found by the Babcock test applied to the cream The overrun is higher in this case because the loss in the skim milk is not included and the skilled creamery operator is able to control the composition of the butter very closely.

Form of Keeping Records. In keeping records of the production of individual animals, one of the first essentials is to arrange a system to be followed. In many cases those who have undertaken to keep records of milk and fat production have not carried out their intentions long, for the reason that they started without any carefully prepared plan and with no convenient way to keep their records.

Fig. 31 shows a portion of a sheet to be used in the barn for

DAILY MILK RECORD

Owner of Herd . . Address Month of . 19

Name or Number	
1	A M
	P M
2	A M
	P M
3	A M
	P M
4	A M
	P M
	A M
	P M
30	A M
	P M
31	A M
	P M.
Total pounds milk	
Test (per cent butterfat)	
Total pounds butterfat	

FIG. 31. Daily milk sheet Blank sheets may be purchased for barn use Those carrying a complete record for the month are usually preferred, especially for average farm herds (Adapted from chart issued by Michigan State College Dairy Department)

recording the milkings. Some use sheets with space for seven days only, although the most common plan is to have the sheet arranged to cover an entire month. The milk scales used should be graduated to tenths of a pound rather than in ounces, as this saves considerable time in adding the sheets. The scales should be hung at a point convenient for the milkers.

The milk sheet is best placed on the wall beside the scales. Without some means of protection the milk sheet becomes badly soiled before the records are completed and it is ready to be removed. Various forms of holders have been designed for this purpose. Plans for such devices may be obtained in some cases from the state agricultural college.

Adding Records. Part of the value of keeping records is realized from day to day, but their full value comes only from having proper totals for each month and, finally, for the year. Adding up the milk sheets is a tedious task if it is done without the aid of an adding machine. Some farmers find it possible to make use of adding machines in local banks or to employ someone having the use of such a machine.

Where no assistance of this kind is available it is suggested that children within the family often show considerable interest in adding these records at the end of each month.

A Permanent Record. It is customary to think in terms of calendar months, and in keeping records the best plan to follow is that of using the calendar month as the unit. After the totals by months are available there is seldom occasion to make use of the daily records. It is desirable then to record these totals in a permanent form in a book which will be kept in the office for reference. The form in which these records are kept is very important in determining their value to the cattle owner. Books designed for this purpose are on the market, and separate printed sheets can also be purchased from many supply houses. These sheets can be used in connection with pedigree sheets or in looseleaf forms.

A form used for many years by the author, and which meets the requirements exceptionally well, is illustrated in Figs. 32 and 33. This form of record is especially valuable for the purebred herd. The illus-

Name Herd No Color When Dropped Registry No

SEMI OFFICIAL AND HERD TEST RECORDS

Age	No Days	Milk	% Fat	Fat

AGGLUTINATION REACTION FOR CONTAGIOUS ABORTION

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec

PRODUCE

Date of Service	Times Bred	Conceived	Sire	Due to Calve	Date of Calving	Sex	Weight before Calving	Weight of Calf	Weight after Calving	No Herd	Name and Number of Calf	Disposition

FIG 32 *Form for a permanent herd book record* Suitable blank forms are essential for record keeping Such a form combined with the reverse of the sheet (Fig 33) as a loose leaf for a herd book provides all the information necessary to keep for each cow in the purebred herd

MILK AND BUTTERFAT RECORD

Name............................ Disposition.......................

Year	Lbs. Milk	% Fat	Lbs. Butter-fat	Lbs. Milk	% Fat	Lbs. Butter-fat	Lbs. Milk	% Fat	Lbs. Butter-fat	Lbs. Milk	% Fat	Lbs. Butter-fat	Lbs. Milk	% Fat	Lbs. Butter-fat	Lbs. Milk	% Fat	Lbs. Butter-fat	Lbs. Milk	% Fat	Lbs. Butter-fat
January																					
February																					
March																					
April																					
May																					
June																					
January																					
February																					
March																					
April																					
May																					
June																					
Record 365 Days																					
Complete Period																					
No. Days																					

FIG. 33. Form for keeping permanent records. Such a form will serve for a complete record for seven years. It is best to have this as a loose leaf so it may be taken from the herd book and filed away. This is the reverse side of Fig. 32.

tration shows the sheets printed and perforated for use in a looseleaf book The pedigree and record of progeny appear on one side of the sheet, and the production record by lactation periods on the reverse side Two holders are needed when the looseleaf system is used In one are kept the leaves bearing the records of the cows in the herd, in the other holder are placed the leaves for the animals which are no longer in the herd

FIG. 34 A poor producer discarded as the result of dairy herd improvement testing *Under good conditions she failed to produce at a profit Her owner* failed to realize how inferior she was until he started to keep records

It will be noted that the months of the year are arranged in order, 24 months being allowed for in each column In entering a years' record of a cow, the first month's record is entered opposite that month the first time it appears, beginning at the top of the column It leaves room in every case for at least a 13 months' record Each new lactation period should be begun in a new column

At the end of the milking period the record is added and the total inserted In finding the average percentage of fat, the total fat yield

should be divided by the total milk to give the true average per cent of fat. An average found by adding the monthly tests and dividing by the number made does not give a true average test but usually a figure somewhat too high, since the amount of milk is usually small when the per cent of fat is the highest.

DAIRY HERD IMPROVEMENT ASSOCIATIONS

Limitations of Individual Testing. There are several reasons why testing has been neglected by many dairy farmers who really appreciate the necessity and the value of testing from the standpoint of herd improvement by culling unprofitable cows. It must be attended to systematically and regularly in order to secure satisfactory results, and on many farms there are seasons when rush of other work will cause the testing to be put aside. Again, the keeping of useful records involves a certain amount of book work and calculating—which is ordinarily put off from time to time, until the accumulation is so great that no one has the courage to undertake the task of bringing the records up to date in order to determine the year's production of the various cows. Nothing can be accomplished this way, and herd improvement is at a standstill.

Origin of Cow-Testing Associations. The first co-operative cow-testing association was organized in Denmark in 1895. It became very popular with the Danish farmers and through their advocacy has spread to every dairy country of the world. The first association in this country was established at Fremont, Newaygo County, Michigan, in 1905. From that time the movement has been gaining steadily, and in 1953 there were 2,151 such associations scattered throughout the various states with 40,983 herds and 1,226,588 cows on test. They are now known as Dairy Herd Improvement Associations. The average production of all cows in 1952 was 9,192 pounds of milk and 366 pounds fat.

Organization. The plan of organization is simple. Fifteen to twenty-five or more farmers adopt the usual form of constitution, elect officers, and agree to put a certain number of cows on test. The cost per cow for one year varies, depending on the locality, wages paid, and number of cows pledged. The association then hires a com-

petent tester to do the work, and he visits the farm of each member once a month throughout the year He weighs, samples, and tests the milk of each cow individually The milk should be weighed by the milker for the remainder of the month and entered on the barn sheet The tester totals the milk sheets calculates the amount of fat, and also determines the cost of feed consumed by each cow The member-

FIG 35 A highly profitable Holstein cow Picture taken at last milking com pleting a yearly record of 27 652 pounds of milk and 966 pounds of fat at seven years of age

ship in one of these associations is insured an accurate monthly test on each cow and a complete summary of production and feed costs at the end of the year

Other Advantages There are additional advantages which accrue to the members of Dairy Herd Improvement Associations Testers are often able to give advice regarding the feeding of the cows and to suggest beneficial changes in the rations Testers may also help compile useful information regarding bulls used through dam-daughter comparisons and assist in intelligent sire selection They come in

contact with different dairymen throughout the month, and in the course of their duties they gain much valuable information which they will gladly pass on to other farmers. Joining a test association is usually followed by a renewed interest in the dairy herd and a more careful study of the cows as individuals. Of course, the primary purpose of all this work is to afford a definite line on the producing ability of the cows in the herd; and when this information is secured, proper use should be made of it by removing the unprofitable cows, thus raising the average production. As a concrete example of the results which will follow if this is done, in ten years of cow-test association work the average yield of all cows in the original Newaygo County, Michigan, association was increased from 5,354 pounds of milk and 215 pounds of fat to 8,802 pounds of milk and 375.5 pounds of fat. This first cow-testing association in the United States celebrated 50 years of continuous operation in 1955.

The rapid extension of dairy herd improvement associations and the appreciation of the value of carefully kept private records are affording more and more information on which to base the purchase of foundation stock for a dairy herd and to improve the production of herds by culling. In the absence of some accurate record of performance, the dairyman is continuing to work in the dark.

Judging a Cow by Her Two-Year-Old Record. In keeping records for the purpose of culling out unprofitable cows, the question arises as to how long a young cow should be kept in the herd before it is safe to decide if she should be kept permanently. If a two-year-old produces 150 pounds of fat in a year, does it mean that she will not be a profitable animal when mature? If a group of heifers produce 250 pounds of fat each as two-year-olds, is it probable that some will be excellent cows and some inferior when mature? In other words, to what extent is it safe to judge a heifer by her milking period?

The results of a study made by the author of the lifetime records of 98 cows representing three breeds is given in Table 21.

In this table the records studied are grouped according to the production of the cows as two-year-olds. For example, among the 98 records studied, two cows produced less than 100 pounds of fat in the first lactation period as two-year-olds. Records were available for

seven lactation periods of these same cows when mature, and the average production was 120 pounds of fat

The data presented show conclusively that the record of the two-year-old bears a very definite relation to her production when mature In each case, with an increase in two-year-old records a corresponding increase is found for the group when mature

Table 21 Relation of Two-Year-Old Records to Mature Records

NUMBER OF COWS	2 YEAR-OLD RECORD LBS	TOTAL NUMBER LACTATION PERIODS	AVERAGE FAT YIELD MATURE LBS
2	Less than 100	7	120
9	100 to 150	29	183
28	150 to 200	117	261
26	200 to 250	103	292
21	250 to 300	103	324
9	300 to 350	40	373
3	350 and above	12	449

It is clear from this table that a two-year-old record is a reasonably safe basis upon which to judge the future value of the animal If the animal has the proper inheritance to be a first-class dairy cow, the fact is evident almost as soon as she freshens the first time There is considerable variation between individuals which is not shown in the table, although the greater number follow rather close to the average

If the 98 cows had been culled by their two-year-old record, in only one case would injustice have been done

Selection by One Year Record. From the above study it seems safe to select the profitable from the unprofitable after one year in milk. If the cow at first freshening is reasonably mature and in good condition and if no sickness or accident occurs—in other words if there is no reasonable excuse for low production—it will be entirely safe to judge the cow upon the records for this first year Perhaps the most practical plan to follow when the cow proves inferior as a two-year-old and is to be sold for beef is to keep her until she freshens the second time She may then be milked so long as her milk production continues to be profitable, and then she may be sold By this plan

the owner has the calf, and oftentimes the calf from an inferior cow, if sired by a high-class bull, will be a satisfactory producer.

Unless the breeding of the cow is such that the owner desires to be very certain before condemning her, he may go even further than suggested and decide within a few weeks after the first freshening whether or not the heifer is one to be retained. In this case, special care should be given that all conditions are favorable—in other words, that she has had a fair chance.

Mature Equivalent Factors. The use of mature equivalent factors or age conversion factors has been rather general during the past several years although it is recognized that they have definite limitations. Through their use, an attempt is made to get a uniform comparison of individuals by comparing records made at various ages and often on a different milking schedule. The Bureau of Dairy Industry has prepared a table which proves useful in contemplating comparable production records used in proving sires through dairy herd improvement association work. They have compiled new tables for the Holstein and Jersey breeds and are working on new tables for Guernseys, Brown Swiss, and Ayrshires.

Although correction factors are an asset to the breeder and investigator in getting some comparable basis of studying the transmitting abilities of cattle, one must remember that these factors have limitations. Environmental factors will always play a part in influencing production. It is doubtful if a mathematical formula will ever be evolved which will compensate for these many variable environmental factors. Also, correction factors are much more usable in dealing with numbers rather than individuals.

CHAPTER XIV

Selection, Care, and Management of the Sire

GENERAL IMPORTANCE OF SELECTING THE SIRE

It has been pointed out in a previous chapter that the question of getting for immediate use a herd that may be kept as a profit is a question of the selection of the individual cow It is generally conceded that, taking all dairy cattle into account, about one third of those raised are unsatisfactory and have to be culled out as unprofitable when records are kept This results in an enormous loss of feed and labor in the aggregate, in raising unprofitable animals as well as keeping them until their worthlessness is proved One of the first questions to arise is whether these inferior animals which must be culled are the result of inheritance or of environment In other words, is a good or inferior cow born what she is, or is she made what she is by feed and management when young? The relation of environment during the growing period to the dairy qualities of the mature cow is treated in detail in a later chapter It will suffice to say here that experimental results lead to the conclusion that the ability of the cow to produce milk—the dairy temperament, as some term it—is almost entirely a matter of inheritance The high-class or the inferior cow is born that way, and not made so by any special treatment when young In fact, within the limits or ordinary practice, the manner of feeding and management of the growing heifer has little if any relation to the efficiency of the mature cow as a milk producer

If the difference between a cow having a capacity of 10,000 pounds of milk in a year and another that barely reaches 4,000 is a question of parents, it certainly becomes a matter of no small importance to see that the proper parents are provided. Selection of the individual cows must be depended upon to insure a satisfactory herd for present use. With the same emphasis, it may be said that the problem of getting a better herd for the future is a question of having good young stock coming on, and is a matter of breeding. The question of breeding is primarily that of the selection of the right sire.

FIG. 36. These 21 cows, all in the herd of the Michigan State College, have each produced over 500 pounds of butterfat in a yearly lactation They represent five breeds and are the daughters of proved sires in all cases

Sire Half the Herd. More than one hundred years ago one of the great English breeders, looking back over the activities of a lifetime spent in breeding livestock, summed up his experiences in the words, "The sire is half the herd." This statement has ever since been accepted as a fit expression of a most important fact, and has become an axiom of livestock breeders the world over.

Every owner of livestock who gives careful thought to the problem of herd improvement realizes that the main chance for the rapid improvement of a herd lies in the introduction of better blood through the sire No one would recommend the purchase of a high-class cow and a medium bull as a means of improving a herd Every animal raised gets half of its inheritance from the sire From the first cross with a registered bull the offspring of a scrub herd have one half improved blood A second cross raises the proportion to three fourths and a third cross to seven eighths When this proportion of improved blood is reached, the animals have essentially the characteristics of the breed represented by the improved sires, and if the inferior animals are culled out, the dairy qualities should be practically the same as for registered specimens of the breed The real objective of breeding operations should be not to raise a few great producers but to raise a high percentage of efficient animals By proper attention to breeding—and especially to the selection of sires—it should be possible to reduce the number of culls until ultimately not more than one in ten of the heifers raised need be culled

Results from Using a Registered Bull One of the most striking demonstrations regarding the value of registered bulls as a means of increasing the productive capacity of a dairy herd is shown by results obtained at the Iowa Experiment Station[1] in one of the early experiments in breeding A group of typical native cows was brought from an isolated locality in the Ozark region After reaching the experiment station these cows received the same treatment as that given the regular dairy herd The cows were divided into three groups for breeding purposes The original cows in one group, and their descendants, were bred to Holstein bulls, another group to Guernseys, and the third to Jerseys The thirteen original cows with a total of 74 lactation periods averaged 3 991 pounds of milk and 187 pounds of fat. Thirteen daughters of these cows by registered bulls representing the three breeds for a total of 40 lactation periods averaged 5,556 pounds of milk and 253 pounds of fat—an increase in milk of 39 per cent. Records are reported for five cows of the second generation

[1] McCandlish, Gillette and Kildee Iowa Agricultural Experiment Station Bulletin 188 (1919)

of grades carrying 75 per cent of improved blood. These animals, including a total of six lactation periods, averaged 8,401 pounds of milk and 358 pounds of fat—an increase over the original scrubs of 130 per cent in milk yield and 109 per cent in fat production. It was noted that the improved blood resulted in a decided increase in persistency of milk flow.

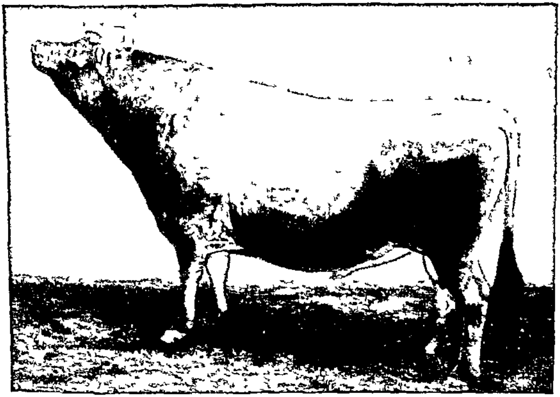

FIG. 37. Fauvic Knight's Prince Purchased as a proved sire after a study of the records of his first seven daughters. Remained in active service until fourteen years of age

Another instructive example of the possibilities in the way of improving the production of a dairy herd by means of a registered sire is found in the results from the herd owned by the Grand Rapids, Minnesota, Sub-Station. A group of cows of native and mixed blood was purchased as the foundation for a herd. The purpose was to demonstrate the possibility, and the methods, of building up a grade herd under practical farm conditions. Complete milk and fat records were kept from the beginning The average production of the original herd was 196 pounds of fat. Ten years later the average of the herd, numbering 41 animals, was 5,721 pounds of milk and 280 pounds of

fat By further culling the herd to 27 cows, three years later an average production was reached of 7,184 pounds of milk and 358 pounds of fat A comparison is possible between records of 19 common cows in this herd and of their daughters by a registered dairy sire These 19 common cows averaged 4,570 pounds of milk and 196 pounds of fat, as compared with 5,028 pounds of milk and 251 pounds of fat from the daughters—an increase of 55 pounds of fat, or about 30 per cent, to be attributed to one cross of improved blood

A Guernsey bull was exhibited at the National Dairy Show in 1921 with ten of his daughters that exceeded the yearly records of their grade dams by an average of 119 pounds of fat

By the use of registered bulls the average yearly milk production of a California herd, composed originally of inferior animals of mixed breeding, was increased from 5,818 pounds of milk to almost 10,000 pounds

The records from a bull association in Maryland give the production of 21 cows in comparison with that of their daughters by a registered bull of a dairy breed The dams averaged 5,560 pounds of milk and 219 pounds of fat while the daughters by the pure-bred sire averaged 6,523 pounds of milk and 263 pounds of fat The increase to be credited to better inheritance was 1,414 pounds of milk and 62 pounds of fat yearly for each daughter Any number of examples of equal significance could be assembled and thousands of farmers have experienced the same results in their herds

Economic Value of Registered Sires Still another striking example of the economic value of the registered sire is shown by a survey made by the County Agricultural Agent of the dairy farms of Lake County, Illinois The survey included four hundred and forty-two farms selling milk and using a total of 7,045 cows The results are shown in Table 22

Note the income per cow on those farms which have used registered bulls for a term of years, it is approximately $100 above that of the herds where grade or scrub sires were in use

Only the most careful consideration and analysis on the part of the reader will reveal the full significance of these figures The striking relation between the amount of milk and fat produced and the

Table 22. Results of Using Registered Bulls
(From a Survey of Lake County, Illinois)

SIRE USED	NO. FARMS	NO. COWS	MILK SALES PER COW PER YEAR
Registered, females registered	56	941	$284
Registered 5 yrs. or more	95	1,610	267
Registered 2 to 4 years	125	2,098	221
Grade or scrub	214	3,160	173

economy of production has been pointed out in another chapter and an analysis of the causes made. The analysis shows that the overhead expense of keeping the cow—including ration for maintenance, labor, barn room, interest, taxes, and risk of death—are practically the same, regardless of the amount of milk produced. The high-producing cow does require more feed than the low producer, but, since maintenance is the same, the additional nutrients are used directly for milk production. In a previous chapter it has been pointed out that the cow producing 300 pounds of fat a year requires about 25 per cent more feed than one producing 150 pounds.

The Registered Bull in Grade Herds. Let us make an analysis of the figures from the Grand Rapids Sub-Station herd cited earlier in this chapter. The original herd averaged 196 pounds of fat and 4,666 pounds of milk. The herd after thirteen years averaged 7,184 pounds of milk and 359 pounds of fat, an increase of 2,518 pounds of milk and 162 pounds of fat. Assuming these cows were milked six years each, the total increase in production per cow for those having the improved blood would be 15,108 pounds of milk and 972 pounds of fat over the average of the original unimproved herd. Under present prices of $3.50 per hundred pounds for milk, the additional milk would be worth $528.78. If the 972 pounds of fat were sold at 60 cents a pound, the increased income would be $583.20. Against this it would be fair to charge the cost for additional feed which would be necessary on account of the greater production. This additional amount would in this case not be over 900 pounds of grain a year and a small increase in roughage. If concentrates are worth $40 a ton, the additional feed would for the six years amount to about

$110 a cow, leaving a net gain of $418 78 if the milk were sold at the figure mentioned, or of $473 20 if the fat were marketed The use of registered bulls in a grade herd like this would make possible an annual income of about $90 more for each cow than if a registered bull had not been used

The data from the Iowa Experiment Station show an increase of 66 pounds of fat yearly from the daughters of a registered bull as compared with the scrub dams At 45 cents a pound of fat, the daughters gave an income of $29 40 a year more than their dams Assuming that one half of the offspring were males and of no value and that the heifer calves were raised and milked six years each, a service fee of $88 20 could have been paid for each scrub cow bred to the registered bull It is clear that given a herd of low-producing cows, and looking forward for a term of years the axiom, "The sire is half the herd," is really a conservative statement.

Importance of the Sire in the Registered Herd. With the registered herd, even more is at stake in the selection of the herd sire than when the herd is a grade one used only for producing market products Furthermore, with each progressive stage of development the problem of getting a sire that will result in improvement becomes increasingly difficult. In highly developed herds it becomes a serious question to select an animal for breeding purposes good enough to hold the advancement that has been made While almost any registered bull of good inheritance should increase, or at least maintain, the standard of an ordinary grade herd, only an animal of the best proved inheritance will make it possible to maintain, to say nothing of improving the production of, a highly developed registered herd All successful breeders recognize that the whole future of the herd is at stake when the bull is selected. As soon as one animal is decided upon, they begin considering what to use next.

Breed History Made by Great Sires. A study of the history of unusually successful breeders of the past will generally reveal that their success was based largely upon one or more great transmitting sires The great work of the Colling brothers in establishing the Shorthorn breed in the eighteenth century was based largely upon the bull, Favorite The early popularity of the Jersey breed in America

was largely the result of the great transmitting bull, Stoke Pogis 3rd. This bull was the founder of a family that was bred successfully for forty years. Golden Lad was an important influence for more than fifty years after his death. The Guernsey bull, May Rose King; and the Holstein, Hengerveld De Kol; the Brown Swiss bull, Jane's Royal of Vernon; and the Ayrshire, Penshurst Man O'War, made famous the herds where they were owned and left a permanent impress upon their breeds.

Difference in Transmission of Dairy Qualities by Different Bulls. One of the striking and important facts that has to be taken into account is the wide variation in the transmission of dairy qualities by different bulls. This fact is illustrated in Table 23, compiled by the author from the records of the Jersey herd owned by the University of Missouri. Members of this herd were all descendants from three cows, and complete milk and fat records were available for thirty years. The comparisons are between the production of the daughters of various sires used and the dams of these daughters. The records given appear low, but this is explained by the fact that all the daughters of each sire are included in each case, that two-year-old records are included, and that the cows were not pushed for high production. The conditions under which the herd was maintained during the long period represented did not vary sufficiently to influence the data materially. In case a daughter had only two or three lactation periods the comparison was made between these and the corresponding periods for the dam. The records for the daughters of Sultana's Virginia Lad represent two-year-old records only. The number of animals represented in the various groups varies, but averages about ten. The figure 4,381 for example, given as the milk production of the daughters of Missouri Rioter, is an average of the production of each daughter of Missouri Rioter, which is found in turn by taking the average of all the lactation periods of the particular animals.

What Is the Value of a Bull? Very interesting and instructive comparisons may be made of the comparative values of these bulls. The daughters of Lorne of Meridale, for example, averaged 1,491 pounds of milk more per year for their entire lifetime than did their dams. Eleven out of a total of thirteen were superior to their dams.

Table 23. Influence of the Sire Shown by a Comparison of the Records of Daughters with Dams

	Averages for all lactation periods	
	Dams	Daughters
Missouri Rioter		
Milk Yield, lbs	5,380	4,381
Per cent fat	4 35	4 93
Yield of fat, lbs	234	216
Hugorotus		
Milk Yield, lbs	4,969	4,576
Per cent fat	4 66	5 35
Yield of fat, lbs	231	216
Lorne of Meridale		
Milk Yield, lbs	4,559	6,050
Per cent fat	4 85	4 81
Yield of fat, lbs	221	291
Missouri Rioter, 3rd		
Milk Yield, lbs	4,775	8,005
Per cent fat	4 98	4 80
Yield of fat, lbs	238	384
Minette s Pedro		
Milk Yield, lbs	5,321	5,376
Per cent fat	5 03	5 04
Yield of fat, lbs	268	271
Daisy's Prince of St Lambert		
Milk Yield lbs	5,362	3,932
Per cent fat	5 07	5 03
Yield of fat lbs	269	198
Brown Bessie's Registrar		
Milk Yield, lbs	6,069	4,607
Per cent fat	4 94	4 97
Yield of fat, lbs	300	229
Fairy s Lad		
Milk Yield, lbs	6,219	6,169
Per cent fat	4 80	5 24
Yield of fat lbs	299	323
Sultana's Virginia Lad*		
Milk Yield lbs	5,349	7,722
Per cent fat	5 17	5 76
Yield of fat lbs	277	445

* Records of both dams and daughters are as two-year-olds.

If thirty daughters of this bull had been milked in one herd, their total production per year would have exceeded that of their dams by 44,730 pounds. At $3.50 a hundred for milk the income would be $1,565 per year more than for their dams. If the animals were daughters of Missouri Rioter, they would have produced 999 pounds each less than their mothers in a year, or a total of 29,970 pounds of milk less than their dams. At $3.50 a hundred this would be a decrease of $1,049. It would make a difference of $2,614 in the gross income whether these cows be daughters of Missouri Rioter or of Lorne of Meridale. If we make the comparison directly from the average yield of the daughters, the difference would be 50,070 pounds of milk.

The figures for the daughters of Sultana's Virginia Lad include the first sixteen daughters sired by this bull in the University of Missouri herd. They averaged in their first lactation period 2,373 pounds of milk and 168 pounds of fat more than their dams at the same age. On a percentage basis, this is an increase of 44.4 per cent in milk and 60.7 per cent in fat. The type of daughters was also far superior to that of their dams. The value of such a bull in a herd can hardly be overestimated. The fact should also be noted that all the daughters are included. By using figures from a selected group representing only a portion of the offspring of an animal, it is often possible to misrepresent the real breeding qualities of the bull in question.

Another remarkable bull was Emblagaard Tritomia Homestead, a Holstein owned by the University of Illinois. The yearly production of his first ten daughters as two-year-olds and of their dams at the same age is as follows:

	DAMS	DAUGHTERS
Lbs. milk	9 594	13,504
Per cent fat	3.21	3 47
Lbs. fat yield	308	469

The average increase in production of the daughters over that of their dams was 3,907 pounds of milk and 161 pounds of fat. On the percentage basis, the increase was 40.7 per cent in milk and 52.2 in fat.

Prepotent Sires Found in All Breeds A large number of very striking examples could be assembled showing the remarkable transmitting ability of certain well-known bulls in all the dairy breeds This marked capacity to transmit a character or characteristics to offspring is known as *prepotency* One of the most striking of these examples is that of the Holstein bull Sir Pietertje Ormsby Mercedes The ability of this animal to transmit milking qualities was phenomenal Sixty-one daugthers of this bull, of which forty-two were not yet mature at the time the record was made, averaged on official test 17,816 pounds of milk and 643 pounds of fat in a year Of these, fourteen exceeded 800 pounds of fat and twenty produced in excess of 20,000 pounds of milk during the year of test This remarkable bull at the same time was an outstanding animal of the breed in conformation and transmitted this to his offspring to a high degree as is shown by a long list of prizes won at the leading shows over a term of years It has been largely through the descendants of this bull that the Ormsby family has become so popular

Fauvic Knight's Prince, a Jersey sire of recent years, is another outstanding example of a prepotent sire The first seventeen daughters of this bull freshening at an average of 26 months averaged 558 pounds of fat in a year under official test

Cause of the Wide Variation in Prepotency of Bulls It is easy to understand why a registered bull should transmit the characteristics of his breed more uniformly than does a scrub, or even a grade animal His ancestors have been selected for generations with a certain purpose in view However, it is not so clear why there should be such extreme variations in the way registered bulls of the dairy breeds transmit milking characteristics Why should the daughters of one bull be uniformly high producing animals while those sired by another are medium or even inferior? The variation is undoubtedly to be attributed to a difference in the combination of hereditary factors

Continued Improvement of Breeds Difficult. The dairy cow of today has been developed until she is an abnormal animal from the standpoint of nature There is, of course, no means of knowing the capacity of the original wild cow as a milk-producing animal It is safe to assume that she produced not over 1,500 to 2,000 pounds of

milk in a lactation period of five or six months. The high-class dairy cow of today produces more milk in a month than her wild ancestor did in an entire milking period. Moreover, she will continue to produce milk at least ten months out of each year. The production of large quantities of milk is not an original or ancestral characteristic of the species, but a specialized one developed through purposeful breeding. Until the inherited factors responsible for the ancestral characteristic (low milk production) are completely bred out of the herd, a process which may take many, many generations, the new or specialized characteristic (high milk production) is easily lost and many animals revert to the older type of unprofitable producers that have to be culled from the herd Unless constant selection of breeding stock is made, not only will no progress be made but the tendency will be actually backward. To retain the milking qualities at a uniform and satisfactory level requires the use of a prepotent bull better bred than are the cows. To improve or even retain the standard in a highly developed herd becomes exceedingly difficult.

THE BASIS OF SIRE SELECTION

The selection of the dairy sire is generally based upon one or more of four points:

1. Breed.
2. Type and appearance.
3. Pedigree, including with this all facts regarding ancestry, such as milk records.
4. Characteristics of offspring.

In most cases more than one of these points are taken into account. For example, the most common basis for selection is by breed, type, and pedigree combined.

The Breed. As a rule the question of what breed the sire shall represent is answered at once by the fact that the herd for which the sire is to be purchased is either a grade or a registered herd which is maintained according to a well-defined breeding plan on the part of the owner. An owner of such a herd is not satisfied by selecting a bull by breed alone, however; he also considers type and pedigree. Many owners of herds less well developed do buy bulls with little

attention to anything other than knowing the animals belong to the breed they are using Although the question of crossing is considered in detail elsewhere, warning may be repeated here against unnecessary crossing of breeds The bull selected should be registered of the breed to which the cows belong, or, in case grading up from mixed stock is to be begun, of the one selected as best suiting the purpose Under these conditions it is often necessary and advisable to use a bull on cows containing more or less blood of other breeds However, deliberately crossing breeds with the expectation of getting better results is to be avoided generally

Type and Appearance There is some difference of opinion as to the proper weight to be given to type in the selection of a bull The emphasis to be placed upon type depends mostly upon the objective of the purchaser If the purpose is to develop a herd for milk production with little attention to show ring type in the cows, less attention is necessary to this point than is desirable when the animal is to be used in a registered herd where beautiful conformation is a strong asset It is becoming more generally recognized that there is little relation between the show type of a dairy bull and the milking qualities of his daughters The beef-bred bull shows in his own bodily conformation the beef qualities for which he is bred and which he may reasonably be expected to transmit to his offspring Likewise, some conclusions may be drawn from the type of a dairy-bred bull as to the conformation of his daughters Milk production, however, is the function of a gland, and has little to do with body conformation For this reason the appearance of the bull offers far less basis for judgment as to the milking qualities he will transmit than it does for the probable type of his daughters The type of the bull should not be ignored, since it is important to have cows of good conformation if possible However, for the practical milk producer, animals of milk-producing ability are the first consideration It is a general observation that cows showing superior dairy conformation are also the better producers It is always well to insist that the size of the bull selected be from medium to large for the breed he represents, and that he be full of vigor and nervous energy Many men buy bulls, especially those that command only a moderate price, without know-

ing more than that the animal is purebred and that he is a good-looking specimen. Reasonably good type is desirable, but it would not be advisable to make the decision as a rule on this point alone.

Selecting by Pedigree. A large majority of the bulls are selected largely upon their pedigree and the milk records of their ancestors. A careful consideration of the pedigree, with some attention to the individuality of the animal, is the best means of selecting a bull—next to that of judging him by his daughters. The experienced breeder of purebred cattle has usually become a student of pedigrees and knows how to interpret them. The person who has not had the opportunity to become familiar with the subject should either do so, or preferably get some one with this knowledge to assist him in making his choice. As a rule, it is best for the inexperienced person to go to a reliable, experienced breeder and rely largely upon him to supply what the buyer needs.

The value of the sire's dam. In studying the pedigree, the mother of the animal in question should be given first consideration. Many experienced breeders believe that there is stronger inheritance of dairy qualities from the sire than through the dam. There is some question concerning this view, but at any rate the mother of the bull chosen should by all means be as nearly as possible the perfect cow of the buyer. The buyer should make it a point to see the dam, if possible, and satisfy himself as to her qualities. If the purchase is to be made by mail, a photograph of the dam should be insisted upon. In addition to the dam being an animal of proper size and conformation, satisfactory evidence should be available—preferably in the form of an official record—as to her milk-producing ability. Transmitting ability of other sons or daughters is also of great value. Next in importance to the dam is the sire, to be judged mostly by the dairy qualities of his daughters if they are in milk, by his sisters, and especially by his dam.

Too much attention should not be given to ancestors three or more generations back. Too often the owner of a purebred bull speaks with great pride of ancestors back three to four generations, and at the same time knows nothing concerning the immediate ancestors, even of the dam.

Avoid the unusual. Another important consideration is to make

sure that the dam of the bull under consideration is not an unusual producer in a family of inferior animals Such a cow is not a good dam for a bull even though she may have an excellent record herself If a certain cow is a splendid producer, but the remainder of the family are ordinary or inferior in this respect, she is not typical of her inheritance and cannot be counted on to transmit her own good qualities The chances are that she will transmit characteristics nearer the average of her family The dam, then, should not only have a good record herself but if possible be one of a large group of high-producing cows She should represent a family in which it is common, and not exceptional, for the cows to be high producers The same statements apply to all females in the pedigree, but with less importance to those farther removed from the bull whose pedigree is under consideration If the dam of the sire comes of a high-producing family of this kind it is also significant and greatly increases the chances that the characteristics desired will be transmitted If the sire of the bull under consideration has daughters in milk, naturally they should be uniformly good

It is also well to take into account the opportunity which the animal in question has had to make a showing It is clear that a bull which has a half-dozen high record daughters is not necessarily a good ancestor for a herd bull if he also had three dozen daughters that could not get into the Advanced Register at all Again, a record made in a herd where only ordinary care is given to the cow appears to disadvantage compared with records made in herds where every cow is forced to the limit A bull then, whose daughters have been owned in a herd where every opportunity is given for maximum results will show to an unfair advantage over the bull whose daughters have received ordinary treatment. It is unfortunately a difficult matter, as a rule, to get the information necessary upon which to pass judgment along these lines

Evaluation of records In studying milk and fat records in pedigrees, care should be taken to make certain what the records mean Note whether or not the records are given in terms of butterfat or butter Early records of Holstein cows were often given in terms of

butter calculated on the 80 per cent fat basis, which was misleading. Records of all breeds are now given in terms of butterfat.

Records covering a year should certainly be given more consideration than short-time records. This is especially true with reference to the percentage of fat. A high fat percentage for the first month's test does not necessarily indicate that this test will continue throughout the entire lactation period. It is desirable to know whether records are for 305 days or 365 days and if cows were milked twice or three times daily. Lifetime records covering entire lactations are of course the most valuable.

An unfortunate practice has been in vogue in recent years in the preparation of pedigrees, especially for public-sale catalogues. So much attention has been given to milk and fat records that the attention of the reader is at once attracted to the name of the animal that has no records below. To avoid this situation, records or ancestors or distant relatives are put in the vacant place with an explanatory statement in small type, for example, "By a three-quarters brother to the sire of" followed by the records. The object of such statements is to make the pedigree appear better than it really is, without making any actual misstatements, and to mislead the careless reader.

Pedigree no guarantee. It must be conceded that at times animals selected with the best of judgment and after careful consideration of the pedigree prove very disappointing. Such experiences unfortunately are only too common. Some excellent examples are found among the bulls listed with the records of their daughters in Table 23. Missouri Rioter, Daisy's Prince of St. Lambert, and Brown Bessie's Registrar, all had good pedigrees, but their use was disastrous as shown by the results. The pedigree of Brown Bessie's Registrar was especially strong in records of butter production. Each female in his pedigree for three generations had a record. His dam was a daughter of a bull with over sixty tested daughters. His sire had a very large list of good producing daughters. In these three cases evidently the pedigree was not a reliable indication of the bull. In the same list Missouri Rioter 3rd and Fairy's Lad, likewise selected upon the basis of pedigree, were excellent transmitting bulls, although no one familiar with Jersey pedigrees

would have ranked them above those mentioned which proved to be so inferior In fact it is not unusual for some of the most famous transmitting bulls, like Hengerveld De Kol to show *little or no evidence* of their unusual breeding powers in their pedigree

While a good pedigree cannot always be relied upon to insure a satisfactory transmitting animal, it is the best, and in fact the only, basis for selecting the young and untried animal It should, however, be emphasized here that while selection by pedigree is at times disappointing the results will be reasonably satisfactory in the majority of cases *if proper care and judgment are exercised* In a previous paragraph it was pointed out that the appearance of many cows lacking in what is now considered satisfactory milking ability is *no more* than to be expected in view of the abnormal extent to which the milking functions have been developed The same viewpoint seems sound regarding the difficulty of securing a bull that will transmit dairy qualities to such a degree as to satisfy the modern standard If we were content to use the cow as nature made her, little culling of herds would be necessary and the difficulty of selecting a suitable bull for breeding purposes would vanish

The Proved Sire A man who has a dairy herd already highly developed should, *whenever possible find a bull for a herd sire that* has already demonstrated by his daughters his ability to transmit the dairy qualities wanted Unfortunately the common practice followed by many of using a bull two years and then selling him to the butcher makes it impossible to judge the value of most bulls until too late The movement of forming bull clubs and exchanging bulls among breeders offers great possibilities along this line By the exchange among the groups or breeders it will be possible to retain a bull until he is old enough to show breeding value In this way, many bulls are being discovered that are wonderful breeders These are called proved sires

A study of the methods of the great breeders of the past will show that they followed this plan of judging a bull by his offspring rather than by his ancestors and this was unquestionably one of the main reasons for their success Whenever possible, it is wise to retain a bull until the results of his breeding can be ascertained *Then if his daugh-*

ters are not satisfactory, the sooner he is sold the better. There always exists the possibility of finding a great bull like Hengerveld De Kol, Golden Lad, Penshurst's Man O'War or many others of wonderful prepotency. To be sure, there are many difficulties in getting an animal of this kind, and it is not always possible, or at least practicable, to do so; also some breeder had to select a calf and stake his judgment on the chance that the bull would later prove worthy.

The bull known to transmit qualities of a high order is appreciated today as never before, and is certain to bring a long price once his value is known. As a rule, it is only the breeders of purebred cattle and the Artificial Breeders' Association who can spend the

FIG. 38. Eight unselected daughters of the proved bull, Fauvic Knight's Prince Twenty tested daughters average 663 pounds fat, 13,026 pounds of milk.

necessary time and money to locate a bull of this class. The smaller breeder, however, should always be on the lookout, and occasionally a bull of this class may be located where his value has not been appreciated.

Examples of Proved Sires. Instructive examples of selecting a proved sire are also in Table 23. Both Lorne of Meridale and Sultana's Virginia Lad were purchased as proved sires. In both cases daughters were mature and in milk at the time the bulls were purchased, giving an opportunity for safe judgment as to their transmitting abilities. Sultana's Virginia Lad was purchased to be used in a herd where the cows all had Register of Merit records, although there was not at the time a single Register of Merit record in his pedigree. His daughters, however, were a remarkable lot, uniform in

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type and production, and the private records of the owner showed that they were unquestionably heavy producers Care was taken to learn how many daughters he had and to see all of them, and no inferior ones were found His mother was studied carefully, and found to be a splendid animal and to have a group of excellent sisters by the same sire This bull would have been much more valuable in the beginning had Register of Merit records been made of his female relatives However, when his daughters came into milk, there was no question of his remarkable breeding qualities Records available of his first sixteen daughters in the University of Missouri herd showed an increase in production over the dam in every case, the average being 60 7 per cent increase in total butter fat

Desirable as it is to use only a proved sire, it is generally very difficult to secure one when needed Great bulls are sold for slaughter before their value as breeders is known, and when a bull with great transmitting ability is discovered, he is not usually for sale It is suggested that breeders of registered herds, especially, buy a young bull of good breeding and use him to a limited extent, then loan him out until his daughters come into milk The plan is especially recommended of sending two or three good cows for breeding or of buying semen from a proved and recognized great transmitting sire Bull calves from these matings should then be tried out in a limited way as suggested

Age as a Factor in Selecting the Bull Sometimes the claim is made that a mature bull is more prepotent than a young one, although there is no evidence to prove such an assertion According to the modern view of heredity there is no possible way for the transmitting ability of the animal to change as the result of age An animal of either sex receives a certain combination of hereditary characteristics at the time the ovum from which the animal comes is fertilized This combination determines the characteristics of the animal and what it in turn will transmit A young bull is generally preferred, especially by the average dairyman, mainly because a young one is easier to handle and to ship than an older one Furthermore, on account of improper care the aged bull may be an uncertain breeder The typical farmer buys a bull calf about a year old, keeps him two

years, then sells him to the butcher in place of trading with a neighbor or buying one old enough that his ability to transmit the desired qualities may be judged. The reluctance of many breeders to handle the mature bull is a serious obstacle to overcome in any program looking toward the improvement of the great mass of dairy cattle. The average dairyman prefers to experiment continually with a young bull rather than make use of a proved bull if one has by chance been kept in his neighborhood long enough to make this possible. There is no reason, however, for choosing an aged bull unless evidence is at hand that he has the power to transmit what is wanted. If a bull is to be purchased on pedigree alone, let it be a young bull by all means, since he then has all his life before him. Furthermore, the fact that the heifer calves of a bull are attractive at that age and have indications of making satisfactory cows by no means makes him a proved sire so far as the milking qualities of his daughters are concerned. Oftentimes very promising calves develop into mediocre cows when mature.

Relation Between Bull's Prepotency and the Age of His Dam at His Birth. The question also arises at times if a bull which is the first calf of a heifer is as likely to transmit dairy qualities of a high degree as is a son of an older cow which has made large records. On the basis of the discussion in the previous paragraphs, the answer would be that there is no basis for any such conclusion. It is true that the highest prices are generally commanded by bulls from older cows and that the first calf of a heifer is not so much sought after. This results because the merit of the older cows are known, since they have had opportunities to make official records. The heifer in milk for the first time has her reputation to make as a producer. It is wise not to select the calf from the two-year-old as a future herd sire until the heifer has had opportunity to demonstrate her good qualities.

What Is a Good Bull? This question is often asked and yet is a difficult one to answer. There are many different factors to be considered. The purpose of the bull is to make possible reproduction of offspring. These should be as good as or better than those now in use. They should also be healthy and vigorous and well represent

their breed both in size and type They should be efficient and satisfactory transmitters of ability to produce milk and butterfat and satisfactory reproducers of offspring, and be recognized for longevity and vigor The good bull then must first of all be a proved transmitting sire of all or as many as possible of these desired characters This bull must also be a steady and consistent breeder for many years of service He must also be well trained, easy to handle, and healthy He need not be a "show bull" but must be a "proved breeding" bull

Feeding During the Growing Period The bull calf designed for breeding purposes should be well fed during the growing period, in order that he may develop to the full limits of his inheritance An animal that is poorly fed during the growing period may fail to reach his full size His progeny will not be smaller on account of the sire's being undersized from this cause, but it is impossible to judge from the appearance of the animal whether his small size is due to inheritance or to feed A male breeding animal that is small and undeveloped for his age should always be looked upon unfavorably

The male calf is generally raised with the heifers for the first four or five months, receiving the usual ration of the calves in the herd Skim milk serves the purpose just as well as whole milk, and at times it is actually better At the age of about five months it is well to separate the bulls from the heifers The milk feeding may be discontinued at the usual age of six months, or it may be continued for several months longer for the sake of securing the most rapid growth A rather liberal grain ration should be fed If good legume roughage is fed almost any mixture of grain will serve the purpose Corn and oats in equal parts is a suitable mixture, or equal parts of barley, oats, and bran The addition of a small proportion of oil meal would also improve mixtures of farm grown grains Some prefer to feed the bulls the same grain mixtures as received by the cows in milk, and this should meet all requirements At six months of age, and before weaning, the bull will be consuming about four pounds of grain daily After the milk is removed, the grain ration may be increased to possibly five pounds daily This, fed with good clover or alfalfa hay, will insure rapid growth

Optimum Growth Desirable. While there is no advantage in getting the bull fat while young, on the other hand there is no special harm done if he appears a little smooth in form at this age since this tendency will disappear later and it is desirable that optimum growth be secured. The bull reaches maturity in size at about the same age as the cow of the same breed. Bulls of the Jersey and Guernsey breeds, when well fed, reach their full development of skeleton some time between the ages of four and five years. The animals of all breeds increase in weight for about two years after the skeleton has ceased to grow.

Age for Breeding. Bulls of the early maturing breeds, if well fed, are old enough for light service by the time the age of twelve months is reached. One or two services a week are all that should be allowed from the age of twelve to fifteen months. As the animal becomes older and better developed, the amount of service may be increased. A well-fed, mature animal might serve for a herd of two hundred cows if his services were distributed throughout the twelve months. More recent experience in artificial insemination studs shows that bulls will not stand up to the best continued use if used more than about once or twice a week. As a rule, the greater proportion of a herd is bred to calve at a certain period of the year, and for this reason ordinarily one bull should not be expected to serve for more than about fifty cows. The breeding powers of the bull are at the best between the ages of two to five years. A bull that has been properly handled when young and sufficiently exercised when mature may retain his breeding ability to the age of twelve or fifteen years, or occasionally even longer. As a rule, however, the bull past eight years old is liable to be a slow and uncertain breeder.

Ringing the Bull. When the bull is about one year of age, a ring should be put in his nose as a convenience in handling and as something of a protection in case the bull becomes vicious and attacks the herdsman. A punch made for the purpose and sold by dealers in stockmen's supplies may be used in ringing the bull. The ring is slipped through the opening the punch has cut in the cartilage between the nostrils as the instrument is withdrawn. A trocar such as is used in severe cases of bloat is also used sometimes for the same

purpose The instrument is forced through the cartilage division between the nostrils and withdrawn, leaving the cannula in the opening One end of the opened ring is then passed through the opening as the cannula is withdrawn The ring should be filed or sandpapered smooth after it is closed, in order to remove the rough edges formed by opening the ring and tightening the screw Care should be taken not to lead the bull by the new ring until the soreness in the nose has disappeared

Dehorning the Bull There is some difference of opinion regarding the advisability of dehorning the bull The claim has been made that dehorning reduces the prepotency of the bull There is not the slightest evidence, however, that dehorning has any effect upon the breeding qualities of the animal, but it does undoubtedly injure his chances in the show ring For this reason the bull at the head of a highly developed herd, where it is important to maintain the best possible appearance of the sire, is seldom dehorned However, in herds kept primarily for milk production, and this includes the big majority, the bull is seldom allowed to retain his horns A bull is more or less dangerous under any circumstances but certainly less so when dehorned For this reason it is recommended that all bulls, except those at the head of very valuable registered herds, be dehorned It is best to allow the bull to retain his horns until he is possibly a year and a half or two years old and until he realizes that he has them and for what purpose they are designed If he is then dehorned, the effect upon the bull is much more marked than is the case when the horns are removed during calfhood

Feeding the Mature Bull The bull which has reached his growth should be kept in moderate flesh but never allowed to get fat The animal is in the best breeding condition if fed rather liberally and sufficiently exercised to prevent him from becoming overfat High-quality legume hay such as alfalfa, clover, soybean, or cowpea meets the demand for roughage to the best advantage and should be fed in such amounts as will be eaten readily A mature bull will eat from ten to fifteen pounds if the roughage is of good quality Silage in moderate quantities is fed by some, although there is a rather general belief—for which, however, there is no experimental evidence—that

silage tends to impair the breeding qualities. In addition to a good roughage, the bull will need a limited grain allowance. From four to eight pounds a day is generally sufficient, depending upon the size of the animal. Many cattlemen feed the bull from the same mixture as that used for the cows, and there is no objection to this practice. When the bull receives a legume roughage, a ration containing a smaller amount of protein and less variety of grain will serve every purpose. A mixture of three parts corn or barley, two parts oats or bran, and one part linseed will be entirely satisfactory. Whenever practicable, opportuntiy should be given the bull to secure all or most of his living by grazing for a period each year. A properly built safety lot or pasture should be provided.

Housing the Bull. The bull should not be allowed to run loose in the pasture with the herd. In the first place, it is a dangerous practice, as it gives abundant opportunity for the bull to attack a person unawares, or in a place where escape is difficult. Furthermore, a record of the date of breeding of cows cannot be kept and no dairy herd can be handled to best advantage without such records. Cows are often served younger or sooner after calving than the owner intends. The bull running with the herd exhausts himself and he becomes an uncertain breeder sooner than should be the case.

Bull Pens. A box stall ten by twelve feet is suitable for such an animal, when he is to be kept in the barn, or a strong outside paddock should be provided, with a door from the box stall. In all except severe climates the bull is best housed in a shed built in the paddock as shown in Fig. 39. Such a paddock should always have a well-made breeding chute as is also shown.

Exposure to any but severe weather is beneficial rather than injurious to the breeding bull. Such open-air treatment, with the precaution that the animal gets plenty of exercise, will keep the bull in the best breeding condition, and he will be almost as sure a breeder at eight or nine years as at two. This open-air treatment causes the animal to look somewhat rough, and for this reason does not find favor with those who make a business of selling breeding stock, since the appearance of the herd bull is of importance in making sales.

Exercising the Bull. While nearly all successful breeders keep

the bull away from the herd, there is great need of an improvement in the way the bull is handled when confined. Too often he is confined in a dark, dirty stall without exercise from the time he is a calf. Such treatment is certain to result in weakening of the breeding powers, and often the animal becomes entirely impotent while scarcely more than mature. As a result of such treatment, by the time the sire is old

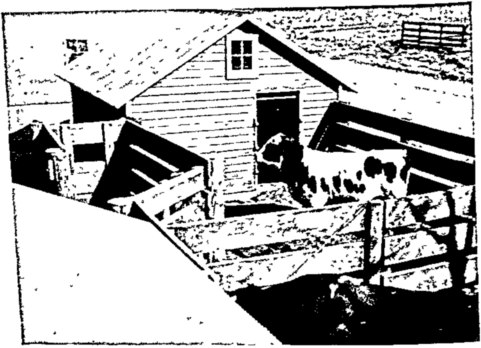

FIG. 39. An inexpensive shed, safety pen, and breeding chute should be on every farm where herd sires are kept.

enough to have daughters in milk so that his value as a sire may be judged, he is too often valueless for breeding purposes. The main points to be observed in keeping a bull in good condition to retain his breeding powers are to avoid excessive use when young and to give plenty of exercise and a moderate ration when mature.

When more than one bull is used, the bulls may be kept together advantageously in a suitable paddock. There is no trouble or danger in keeping two or more bulls of any age together, if they be dehorned.

One of the chief advantages is that they take more exercise than when confined alone.

One of the most common plans of exercising the bull when closely confined is by use of a tread power or specially constructed bull exerciser. The power is adjusted to keep the bull walking at rather a slow pace as long as is wished. Another plan is to arrange a long sweep on a post and tie the bull at the end, and allow him to revolve the sweep by walking. Another plan followed is to arrange an overhead cable upon which a ring is placed from which a chain hangs. The bull is tied to this chain and can walk the length of the cable. A heavy barrel or block that may be bunted about the pen is also commonly used.

Proper Handling of the Bull. The bull of a dairy breed is more liable to be vicious than one of a beef breed, since the former is more active and has greater nervous energy than the more sluggish beef animal. In handling bulls it should always be taken for granted that they are dangerous. It is never safe to trust them. Usually a bull that has been considered perfectly safe is the one who injures someone.

A bull should be treated kindly, but never petted, even when a calf, and anything even bordering on teasing must be prohibited. The bull is best let strictly alone except when it is necessary to handle him He must always be handled in a firm manner and made to understand that a man has power to control him and must be respected. The man handling a bull must not show fear of the animal, and must take care that the bull does not gain the upper hand. The animal should be thoroughly trained to being tied and led when a calf. If this is done, he never forgets it, and may be tied or led at any time later, even if handled only at long intervals.

Care of Legs and Feet. Because they are hard to handle the feet and legs of mature bulls are often neglected. Hoofs should be trimmed regularly and sharp stones or cinders removed. Legs should be examined for stiffness or stall sores. The life of many good bulls has been shortened through neglect or poor management of legs and feet.

Handling the Vicious Bull. Sufficient exercise is one of the most important factors in preventing a bull from becoming vicious. It is also well to have his stall or paddock so located and constructed that

he can see other cattle and the attendants Solitary confinement in an isolated box stall is not conducive toward the development of a quiet disposition in the bull

Care should be taken that the bull never has a chance to learn to use his really enormous strength in breaking fences, gates, tie straps, etc Keeping everything strong and in good repair will do much to hold the bull in subjection An electrified wire on brackets around the inside of the bull pen will effectively prevent his molesting the fence

In leading a bull, a staff should always be used In case he is regularly tied in the barn, a large, strong halter may be used, or a special bull stanchion, as preferred

Artificial Insemination The rapid development in the use of artificial insemination in the United States is bringing about sweeping changes in the handling and use of bulls Cattlemen are now beginning to recognize the importance of really good bulls, and see the necessity of finding these bulls early in their life so that by good handling and efficient use their influence and value can be most fully utilized When artificial insemination is used it is not uncommon now for a bull in a lifetime to sire three to five thousand calves The subject is treated more fully in a separate chapter

CHAPTER XV

Dairy Cattle Breeding[1]

Following the establishment of the breed registry organizations (1868–1880), after the rediscovery of Mendelism in 1900, with the gradual evolvement of breed associations' production testing programs and particularly since 1905, when the first Dairy Testing Organization was conceived in Newago County, Michigan, many persons have been motivated to study the inheritance of dairy cattle characteristics. As production and type classification information accumulates and is analyzed, the genetics of dairy cattle is slowly being clarified. Animal breeding is the study of the application of fundamental laws of genetics and the rules of probability to animal improvement. It would require several complete books to present knowledge and scientific theories covering this subject matter. Consequently the material on dairy cattle breeding is presented in a condensed form, and represents only a brief review of some of the more complete works on breeding.[2,3,4,5] The facilities for projecting known methods of improving producing ability in dairy herds have expanded tremendously through the introduction of artificial breeding as a practical procedure.

Prehistoric Cattle Breeding. As far back as we can trace au-

[1] Author, Dr. N. P. Ralston, Head, Dairy Department, Michigan State University.

[2] Lush, *Animal Breeding Plans*, Iowa State College Press, Inc., Ames, Iowa (1945)

[3] Gilmore, *Dairy Cattle Breeding*, J B Lippincott Company, New York, N.Y. (1952).

[4] Rice and Andrews, *Breeding and Improvement of Farm Animals*, McGraw-Hill Book Co., New York, N.Y. (1951)

[5] Winters, *Animal Breeding*, John Wiley & Sons, Inc., New York, N.Y. (1954).

thentic records, we find animals under domestication, and the earliest reports of domestic animals indicate that they were already much modified from their wild ancestors During the pastoral age, when men wandered from place to place with their herds and flocks, there was more or less interbreeding between the domesticated animals and their wild cousins, which may account for the early establishment of differing species in localities where men roamed

Such early improvement as was shown by the domestic animals over the wild was no doubt largely due to a crude method of selection which is exercised instinctively by any herdsman whose living depends wholly or in part on the produce of his animals This process of improvement was exceedingly gradual, and no very marked progress is traceable previous to the time of Robert Bakewell of Leicestershire, England He is now recognized as the pioneer in what may be called the early improvement and development of modern livestock

Methods of the Pioneer Breeders Bakewell's work was with sheep, horses, and cattle, his method was the fixing of desirable types by careful selection and close breeding of the individuals conforming most closely to his ideal of type He culled closely, leased out sires and later used heavily those whose progeny approached his standards Bakewell s breeding operations were carried on during the last half of the eighteenth century, and though he worked without the aid of modern knowledge of genetics, he nevertheless pursued the course which is now followed in all efforts to concentrate particular characters—that is the close breeding of animals which possess those desired traits His pursuit of this policy led to much adverse criticism by his contemporaries but the splendid success of his methods caught the attention of the thoughtful animal breeders of his day

We find success attending the breeding of Shorthorn cattle by the Colling brothers of England when they adopted Bakewell's methods, although they sought to establish their ideal type through the use of bulls more particularly than through the female lines, and their progress came by using closely inbred bulls Thomas Bates continued the work of improving Shorthorn cattle by concentrating the blood of desirable females and he relied as much on pedigree in selecting

his bulls as on individual excellence. Thomas Booth, Amos Cruickshank, and William Duthie accomplished their splendid results by selecting animals of the desired type and fixing this type by close inbreeding.

Similar work by Dauncey resulted in the establishment of a strain of high-producing Jersey cattle in England, and from this fountainhead the foundation of the early St. Lambert family was drawn.

The Explanation of "Like Begets Like." *In the light of our present knowledge of heredity we can offer an explanation of the* success which attended the practice followed by these pioneers. The results obtained speak for themselves, and these men, guided by their maxim that "Like begets like," set a pattern followed to the present day. Beginning with foundation stock of assorted breeding, but all conforming to a definite type, the surest and quickest method of fixing this type was to breed and interbreed these animals and their descendants, without recourse to outside blood, until such time as the persistence of undesirable traits called for the introduction of a counteracting influence. By pursuing this method of close breeding and careful selection of the best individuals for breeding purposes, these breeders succeeded in causing the resultant offspring in each succeeding generation to become genetically more and more pure (or homozygous) for the desired characters.

The early history of any pure breed invariably shows that the breeders had to resort to the same practice of close breeding and selection. The reason is obvious. The number of desirable animals is limited, and those favored with the qualities most sought for are used to the utmost in the formative period of the breed; and thus the offspring of the best foundation animals are used extensively to perpetuate the blood of the best. Inbreeding is practiced in order to concentrate the qualities possessed by the leading animals of the breed. To test the truth of this statement it is only necessary to trace out to the early foundation stock the pedigrees of animals chosen at random, and find how often the names of well-recognized individuals appear.

The Cells of Animals. Dairy cattle represent a number of different things to different individuals. To those who care for and feed cattle, they may mean work; to others they mean milk, meat, show

ring winnings, local, state, or world s records, to some they mean romance and beauty in their form, and to others they mean profit or loss in a dairy enterprise Few stop to realize that each animal is composed of many millions of tiny cells, in much the same way that a house is built of bricks The concept that tissues are made up of cells was established in 1838 by two German investigators Most cells contain a small structure called the nucleus, which is the center of life and activity of the cell

An animal s body reaches maturity by the growth of cells from the single cell formed by the union of the ovum from the dam and the sperm from the sire Thus it is important to think of animals biologically for sound interpretation of differences between members of the same herd, and the like With the tremendous number of cell divisions and opportunity for environment to affect the life span of an animal, we marvel at the adaptability and orderliness of nature An animal s contribution to man is measured not only by its own performance, but also by its sperm or eggs produced for forming the next generation

From the foregoing, one would deduce that animal cells can be divided into two kinds—somatic cells and germinal cells Somatic cells are the cells of the body Germinal or sex cells are those cells produced by the primary sex organs—the ovary of the cow and the testes of the bull.

All somatic cells adapt themselves to form one of four kinds of animal tissue—epithelial, connective, nervous, and muscle The tissues are then arranged in various fashions to form organs such as heart, kidneys, glands and others These tissues and organs develop in such a manner as to form systems—skin, skeletal, muscular, respiratory, digestive urinary, blood circulatory, lymph, nervous, reproductive, and endocrine Finally the systems are combined and balanced in such a way as to form dairy cattle Over many generations dairymen have tried to select dairy cattle which possess the proper balance of these systems for general efficiency and particularly for efficiency of the secondary sex characteristics—the mammary glands or the udder

Mendel s Concepts Any intelligent discussion of the principles

of genetics must be based on an understanding of the manner in which the mechanisms of inheritance function. For knowledge of the mode of inheritance, we are indebted to the early discoveries of an Austrian monk, Johann Gregor Mendel, who experimented with garden peas, and who by close study of the method of transmission of simple characters such as color and size discovered the principles embodied in Mendel's law. By crossing yellow and green peas he produced a hybrid yellow strain. When these hybrids were planted, the resulting peas were green and yellow in the ration of 1 to 3. All these second-generation green peas reproduced green, but two thirds of the yellow of the second generation behaved the same as the yellow hybrids; while the remaining third of the yellow reproduced yellow.

The chromosomes. There appear within the nucleus of each cell at the time of division a number of microscopic bodies called chromosomes. In the body cells, most of these chromosomes are found in pairs at the time of cell division. A definite number of chromosomes develop in the cells of each particular species of organisms. For cattle, the number is sixty; sheep, fifty-four; man; forty-eight; and so on through the entire animal kingdom. Chromosomes develop from chromatin (dye-absorbing) granules, the individual units of which are called chromomeres; the number of these chromomeres in any cell may run up into thousands. A definite group of these units constitutes each chromosome. The chromomeres are the carriers of all inherited characteristics. The unit of inheritance is called a gene. The genes are supposed to be arranged linearly in the chromosomes. Genes, by interaction with chemical substances in the cells, control the development of characters.

In the mechanism of inheritance we are dealing primarily with the germ cells, a group of cells specialized for reproduction, and it is one of these from each parent which unite to form the new individual. The mature germ cell of the male is called the sperm, and that of the female the ovum or egg. In the formation of mature germ cells, the number of chromosomes is reduced to one half the number characteristic of the body cells of the species. To return to our example of the green and yellow peas, what happens in the crossing is represented diagrammatically by Fig 40.

Mendel's Laws From Mendel's investigations a number of laws were evolved

Unit characters Certain traits or characters of an organism are the result of a gene or single unit of inheritance The expression of such a trait is controlled by a pair of determiners, factors, or genes, e g, red or black color in cattle, horns in cattle—an animal either is horned or is hornless (polled)

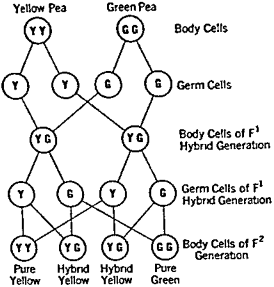

FIG 40 Chart to illustrate Mendel's law Mendel's work was done with peas but the principles he established apply to animals as well as plants

Segregation Breeding investigations combined with microscopic examination have shown that contrasting genes responsible for a character are located at a particular position on a chromosome At the time of formation of the mature germ cells or gametes, these paired determiners or genes split from each other Since these genes split, it is possible for a character to vary in its expression in the succeeding generation and reappear in the third cross If a red bull (bb) is mated to a black cow (BB) all offspring will be black (Bb), but these offspring mated together will produce both types (BB, Bb, bb)

Independent assortment This refers to the independent separation of two or more pairs of noncontrasting genes located on different

chromosomes. This means that one trait can be inherited and behave entirely separately from any other trait. Thus, if a pure breeding polled red cow (PPbb) was mated to a pure breeding horned black bull (ppBB) all offspring would be polled and black (PbBp). The mating of suficient numbers of these latter animals would produce four kinds of offspring—polled and black, polled and red; horned and black, horned and red.

Dominance. If the members of a pair of genes located at a specific position on a chromosome are not the same, the gene with power of expressing itself over its other member is said to be dominant. The other member of the pair which is masked by the more powerful one is said to be a recessive gene. Thus the yellow peas in the F_1 shown in Fig. 40 were of mixed inheritance; however, since they were yellow, it shows that yellow was dominant over the recessive green color.

Equality of sex. Each sex appears to have the same potential in contributing its characteristics to the next generation.

Newer Concepts of Inheritance. Numerous variations of Mendel's laws have been demonstrated in experiments with plants and animals. The more significant ones are mentioned

Linkage. Chromosomes are thought to have genes located along them like beads, and in general these genes tend to stay together and pass on to their offspring. The closer genes are together on the chromosome the more likely they are to be linked and thus inherited with each other. Each pair of chromosomes at the time of splitting goes through several different arrangements in recombining. Some chromosomes have a tendency to break at certain positions and attach themselves to other chromosomes. In this manner there is an exchange of whole portions of chromosomes and all the genes involved. This latter chromosomal behavior is called "crossing over."

Sex linkage. Of the sixty chromosomes of dairy cattle, one pair of chromosomes is concerned with sex determination. Some of the genes located on the female's chromosomes, called an XX pair, are different from those on the male chromosomes, called an XY pair. Thus the expression of factors carried on the sex chromosomes is not always the same when reciprocal crosses are made.

Partial dominance All so-called dominant genes do not exhibit the complete power to mask their corresponding member Thus genes which have this tendency are said to be partially dominant The animal with this type of a heterozygous pair of genes (Rr) will be different from one in which dominance was complete, as indicated in Mendel s law A red Shorthorn bull (RR) mated to a white Shorthorn cow (rr) will produce all roan calves (Rr) Thus the gene responsible for the red color will not completely express itself unless it is pure or homozygous (RR), but in its mixed or heterozygous condition (Rr) it does not completely mask the effects of the white condition (rr), which results in the development of a condition in between the color of the two parents

Epistasis So far the discussion has been concerned with genes located at the same position on the chromosomes or pairs of genes Genes located at one position on the same or different chromosomes may show dominant effects over other genes located at other positions

Multiple factors A number of traits of dairy cattle are controlled by the interaction of a number of pairs of genes Milk production, growth, feed efficiency, and so forth—the really important economic characters—are believed to be governed by multiple pairs of factors or genes which contribute to a trait in varying degrees Thus the performance of the animal is the result of the addition of all these genic actions These characters are often referred to as quantitative or continuous traits

Phenotype vs Genotype The appearance and/or performance of an animal and that of its offspring do not always resemble each other From the foregoing concepts of inheritance this should be understandable In other words dairy cattle do not always transmit to their offspring some of their own desirable, as well as some of their undesirable, traits Some terms to express what an animal is itself and then what it transmits have been coined

The genes responsible for the expression of particular traits are chemical materials that produce substances which together and under certain environmental (feeding, management etc) situations direct a series of events which finally result in the trait we observe This appearance or performance of the animal is called its phenotype It

is dependent upon the behavior of the genes of which it is composed as they interact with themselves and with environmental conditions in which they find themselves from the time of conception until the time they are observed or measured.

An observation or measurement of an animal does not tell the inherited composition of the animal. The known genetic make-up of an animal is called its genotype. The ovum from its dam and sperm from its sire unite and form the fertilized egg. At this time the future genetic composition of the animal is established. It will remain so for the rest of its life. The animal may develop only to a limited extent because of adverse feeding and management conditions but its true genetic make-up will not change. If its true genetic composition were known, the kind of germinal cells it will produce could be predicted. Unfortunately for many traits the exact genetic make-up is never known; therefore, it is estimated by its own appearance or performance, from its ancestors, and from its offspring.

In order that the most rapid progress be made in the improvement of dairy cattle, many phenotypic measurements are needed, such as testing cows to determine total milk and fat production. These then assembled and analyzed for large numbers of closely related dairy cattle and placed on a pedigree will help to evaluate their genotype.

Each Individual a Composite of All Ancestry. Each individual possesses all the normal characters of the race to which it belongs, whether the characteristics are evident or not. In the higher species the characters are so numerous that not all of them can develop in any single individual, the proof of which is found in the fact that it will transmit to its offspring characters which are not apparent in the make-up. While milk production is a function of the female, it is transmitted by the bull as well as by the cow. Recessive characters may be carried for several generations without external evidence, as they are concealed by their dominants, but by a recombination of the genes of two individuals carrying the same recessive character, it may come to the surface. This is commonly spoken of as a "reversion to type." It is the proper explanation for the occasional occurrence of red and white calves in Holsteins.

Variation. In animal breeding it is impossible to mate individuals

which are absolutely identical, and as a consequence, variation is bound to occur This absence of absolute uniformity is readily accounted for by the presence of thousands of factors in the germ plasm of every individual Variability is the universal rule among living beings However, this variability affords the geneticist the means to work improvement through breeding

Variations are attributed to three general causes somatic modification or changes in the body, germinal recombinations or a different assembling of the unit factors in the fusion of sperm and egg, and modifications of the gene or genes, called mutations

The first of these causes is the result of environmental influences which in no way affects the gene, and consequently are not transmissible, since all inheritance comes through gene action and interaction

The second cause for variation occurs when animals of complex germinal make up are mated as many factors are carried through several generations as recessives, and by later combination they segregate and become evident Careful study of the ancestry of both parents for evidence of the previous existence of a supposedly new character should reveal the cause of such variation

Recognizable mutations in higher animals are very rare, and usually lack authentication

Rules of Probability Probability is the ratio of the chances favoring the happening of an event to total number of chances for and against it Before an event can occur a trial must be conducted to provide an opportunity for the event to occur or fail The probability that a Holstein cow will have a black and white calf or a red and white calf is dependent on the cow's being bred to a Holstein sire and then carrying the calf to term for us to observe the results

Events are independent if the occurrence of any one at a given trial does not affect the occurrence of others The chance of obtaining two or more independent events together is the product of the chances of obtaining each separately If a carrier for red and white Holstein sire (Bb) is mated to a similar carrier Holstein cow (Bb), the chance of the calf being red and white is one fourth The chance the sire would transmit the b gene is one half Since the time of segrega-

tion the genes responsible for color would split separately, some sperm cells would carry a B gene and others a b gene. They would be produced in equal numbers. The same would be true for the cow; that is, the egg would carry either the B gene or the b gene. The chance that the b gene from the sire and cow would recombine is one half times one half; therefore, it would occur in one fourth of the cases. If sufficient trials are conducted, the same results can be obtained from tossing pennies, considering the head to be one member of the allelic pair of genes and the tail to be the other. Some events are *mutually exclusive if the occurrence of any one at a given* trial excludes the happening of any other. These rules parallel the genetic laws of segregation and independent assortment of gene pairs. The chance of obtaining any one of several exclusive events is the sum of the chances of obtaining each one alone.

When dealing with genetic characters a sound knowledge of statistics is desirable. It must be realized, however, that statistics provide only a tool and cannot replace a person's judgment in recognizing the characters and knowing the environmental influences, such as care and management, which affect the character as it is observed.

Qualitative Inheritance. Traits are observed as definite things—this or that—such as that some dairy cattle have horns, some are polled, some are males, some are females, some have cataracts, some are free from this defect. In other words, some characters divide themselves into distinct or discrete groups. In general these traits are thought to be inherited by a relatively small number of pairs of genes. These genes may interact with each other to produce the phenotype observed and environmental factors do not seem to modify their expression to a marked degree.

Dominance, partial dominance, and epistasis behave in the simplest form in the expression of these traits. Recent information indicates that gene interaction is apparently more complex than had been anticipated.

Qualitative characters in dairy cattle can be divided into three major classes—lethals, nonlethals (physical and physiological), and color. There is some variation in the expression of these traits, but

in general they are sufficiently alike to be classified into these separate categories

Lethal characters Lethal characters are those conditions which result in premature death under good environmental conditions An occasional occurrence of a defective individual does not mean the defect is always inherited Abnormal embryological development may be the cause as well as diseases, etc Determination of inheritance of a defect requires that a number of these individuals be found A study of the pedigrees of these animals may reveal the nature of the inheritance Generally such traits as lethal defects are observed in herds closely bred It is possible, however, that the mating of two unrelated animals would produce a lethal trait All breeds of dairy cattle have such traits in their genetic make-up Some breeds apparently have a higher frequency of certain genes which will produce some defects Because of the nature of the development, that is, the closeness of breeding and the influence of a few animals in formation of the breed, some breeds exhibit defects more than others

Lethals have been reported from the cattle of many countries L O Gilmore[6] reports twenty-eight lethals, such as bulldog calves, absence of legs, stiff joints, impacted molars, brain hernia, missing leg bones, mummification, lameness, muscle, spasms, fused nostrils, etc For a complete description of these lethals refer to his text Undoubtedly as more accurate and complete information becomes available about dairy cattle, additional lethal traits will be reported

Usually these characters are observed in a herd in a ratio of 7 normals to 1 lethal The majority of these traits are due to pure or homozygous recessive genes (aa) which are located on a pair of the twenty-nine pairs of body chromosomes It might be expected that 25 per cent of the calf crop would be affected This would be true if all the cows were heterozygous (Aa) and they were mated to a heterozygous sire (Aa) (See Fig 40, the F_1 mating of yellow and green peas)

In the majority of cases a herd is free of the gene responsible for the expression of the defect. Occasionally a very small percentage

[6] Gilmore *Dairy Cattle Breeding* J B Lippincott Company, New York, N Y (1952)

might be carriers of one member of a pair of genes responsible for the lethal. A sire which carries the lethal (Aa) is used in a herd that is normal (AA). One half of his calves would be expected to be carriers of lethals (50 per cent AA and 50 per cent Aa). Those heifers (AA and Aa) would then have to be mated to another carrier sire (Aa) before any lethals would appear. The explanation of the 7:1 ratio is given in Fig. 41.

Explanation of the 7 to 1 Ratio

Sire's gametes	A	A	A	a	Heifers' gametes
A	AA	AA	AA	Aa	
a	Aa	Aa	Aa	aa	

FIG. 41. Production of ratio of 7:1 for lethals

From the above figure the calf crop would be expected to be seven normal (3 AA homozygous, 4 Aa [carrier] heterozygous) and one lethal (aa). This emphasizes the importance of keeping accurate breeding and calving records so that pedigrees can be constructed to allow an analysis of the herd. The lethal is produced by the recombination of a recessive gene from each parent. The cow is just as responsible for the lethal as is the sire. The appearance of lethals should be reported to the state agricultural college so that further study can be made.

Nonlethal physical characters. A thorough review of these characters is presented by L. O. Gilmore. These traits can be divided into two groups—nonlethal characters of the skeleton and nonlethal characters affecting the integument, reproductive system, muscles, and senses. Gilmore[7] reports twenty-four known skeletal nonlethals such as horns, head defects, proportionate dwarfism, etc., and forty-four of the other group such as notched ears, smooth tongue, semi-hairlessness, fused teats, testicular hypoplasia, female infertility, congenital cataract, bulging thighs, and so forth.

The mode of inheritance of most of the defects has been determined. In general they are expressed as the result of an autosomal

[7] Gilmore, *op. cit.*

recessive condition Few are dominant For some traits the evidence points to multiple factor involvement The 7 1 ratio is the most frequent one observed

Color inheritance The characteristic color of dairy cattle is one of the most distinguishable features of the various breeds Breeders for many years have emphasized the importance of color markings as a means of characterizing a breed The inheritance of color pattern is fairly well known [8] A number of pairs of genes interacting in various fashions appeared to be involved The black color in Holsteins is dominant to the recessive allele red Occasionally red Holstein calves appear, thus indicating the mating of two carrier animals (Bb), where the recessive genes recombined to give a homozygous (bb) red Holstein The mahogany coloring in Ayrshires varies according to sex of the animal The heterozygous condition in the bulls is expressed as a mahogany color while in the cow the genes interact to give a light brown color Color inheritance may be useful in parentage determination

Quantitative Characters Characters that are expressed in terms of pounds of milk, body weight rate of growth, nonreturn rates, efficiency of feed utilization and the like are called quantitative traits These are the economic characters of primary interest to dairymen They are the result of the action and interaction of numerous pairs of genes probably behaving in much the same way as the genes responsible for the qualitative characters

The multiple factor theory best explains quantitative inheritance Nongenetic factors or environment influence markedly the expression of quantitative traits Since many pairs of genes are involved and since they react differently in varying environments, the performance resulting from these traits is indiscrete and varies widely

The concept of additive inheritance is one which must be understood when considering quantitative characters If a large (A) and a small (a) gene are equal to 5,000 and 2,000 pounds of milk respectively, and a large (B) and a small (b) are equal to 3 000 and 1,000 pounds of milk respectively, then a homozygous cow for these genes (AABB) should produce (5,000 + 5,000 + 3,000 + 3,000)

[8] Gilmore *op cit*

16,000 pounds of milk. The heterozygous cows (AaBb) should produce 11,000 pounds and the homozygous recessive should produce 6,000 pounds of milk. If a heterozygous sire is mated to a cow of similar genotype their offspring should produce milk according to the following ratio: 1 – 16,000 lbs., 2 – 14,000 lbs., 2 – 13,000 lbs., 1 – 12,000 lbs., 4 – 11,000 lbs., 1 – 10,000 lbs., 2 – 9,000 lbs., 2 – 8,000 lbs., and 1 – 6,000 lbs. The individual cow produces only to the limit set by her inheritance; and perfect health, normal functioning of vital organs, a favorable environment, and good training are the essentials required for the complete achievement of her inherent capacities. No individual can influence his heredity, for heredity comes to him from his ancestors through fusion of the sperm of his sire and the egg of his dam. Demonstration of inherited milk-producing qualities can only be restricted by environment. Thus we can see that the range from high to low production will vary considerably just because of varying environmental conditions. Quantitative characters have to be described by indicating the average and the spread around the average. If one postulated there were a large number of genes involved in the expression of milk production, it would be obvious that many different levels of production would be genetically possible.

Standardizing Environmental Effects. Dairymen compare cows with one another and attempt to determine which one is the best not only for the present, but also for producing the next generation. Since milk production is sex-limited the only way to estimate the value of a sire is by evaluating the production of his daughters compared to their dams or to other cows who made their records the same year. Comparisons of this kind can be made on any measurable character of dairy cattle.

Chapters 12 and 13 enumerate many of the considerations for sound selection of cows. Chapter 14 should be reviewed in order to re-emphasize major considerations in sire selection. All selection programs means that cows and sires are compared with each other. As previously stated, milk production is tremendously affected by environment. Studies of the influence of many of these nongenetic considerations have been conducted and correction factors have been developed for some.

The length of records of cows varies widely Some cows can milk only 150 days while others can produce for 365 to 400 days, and in some cases much longer It is generally agreed that cows are the most profitable when they milk ten months, 305 days, and they are dry 60 days This assumes that the calving interval will be twelve months Unfortunately, this condition usually cannot be met The herd does well if the calving interval is 12 8 months The variation between records can be reduced considerably if all cows' records are cut off at 305 days for comparison purposes

Cows increase in production with advancing age until they are 6 to 7 years old then they decline slightly for the remainder of their lives Correction factors have been developed by the Holstein, the Jersey, and the Ayrshire breed associations The Dairy Herd Improvement Section of the Dairy Husbandry Research Branch of the United States Department of Agriculture has developed age correction factors for all breeds from D H I A records These factors are said to correct records to a "Mature Equivalent" (M E) basis They have also developed correction factors for converting the production of cows milked three and four times per day to twice daily milking Standardizing all lactation records for length, age when made, and times milked will reduce the variation between records by about 50 per cent

Other factors such as the rate of feeding, the condition of cow prior to calving, the number of days a cow carries a calf, length of previous dry period, season of calving, and other such factors, as well as the care the herd owner gives his herd will affect production materially The current price of milk has been shown to have a real influence on the level of feeding and other cost factors, which will affect the level of production Within a given state there are marked differences in production between areas There are marked differences between farms within these areas It is much easier and sounder to make comparisons between cows in the same herd than to make them between cows in different herds and in different areas of the state The astute dairyman realizes these differences and tries to correct for them when he is comparing entire herds as well as individual cows within a herd Additional refinements and correction factors are being

sought to aid in a more objective appraisal of the environmental differences.

Repeatability of Records. The performance records, milk production, fat production, fat percentage, type classification, etc., vary from record to record between individuals and for one individual. The genetic make-up of an animal does not change with time; however, the performance or expression of the genes may vary widely because of different environmental conditions throughout a cow's life. For most economic traits governed by multiple genetic factors; environmental factors are unfortunately responsible for more than one half of the total variation of the performance (phenotype) measured. Animals may be affected to some extent by certain permanent environmental conditions, such as pneumonia in calfhood. Also, temporary nongenetic influences may affect the measured performance so that the true genetic potentials of the cows are masked.

Since the individual cow's records do vary widely, how can records of past performance be used to predict her future performance and the performance of the offspring? When a dairyman desires to compare the performance of cows even though they have been standardized for length of record, age, and times milked, how can he consider the differences between records, and the number of records? Proper use of records is just as essential in making improvement of dairy cattle as is getting the original record.

The similarity of successive records of lactation, etc., made by a cow may be calculated and expressed as a mathematical figure called repeatability of records.[9] Repeatability values (r) for single butterfat records, butterfat percentage, and type classification have been found to be approximately 0.40, 0.70, and 0.45 respectively.

Repeatability figures can be used to predict future records of the same cow from her previous records when they are compared to the average of other cows in the same herd the same year. A cow's phenotype or lactation record is the sum of her real genetic potential in a particular year's environment as compared to the other cows in the herd this same year. Therefore, in predicting her future records, the assumption is made that her future environment will not be much

[9] Lush, *op. cit.*

different from her past environment as compared to the other cows in the herd

The future prediction of a cow's production has been called "Most Probable Producing Ability" (MPPA) and "Estimated Real Producing Ability" (ERPA) The method considers the following information as indicated in the formula All records are standardized to a 2X-305-Mature Equivalent (M E) basis (two milkings daily, 305 days, M E)

$$\text{MPPA} = \text{Herd Ave} + \left[\frac{nr}{1 + (n - 1)\,r} \times (\text{Cow's Ave} - \text{Herd Ave})\right]$$

The number of records of the cow is represented by the n and r is the repeatability of a single butterfat record The herd average is an average of all 2X-305 M E records completed by all cows in the herd for one year Considering the weighting factors (confidence about a cow's production) for different combinations of records at a given level of repeatability, it is found they increase as the number of records increase For example, if the repeatability of a single butterfat record is 0 4, as the number of records under consideration increases the weighting factor goes up as follows 1 record – 0 4, 2 records – 0 57, 3 records – 0 67, 4 records – 0 73, 5 records – 0 77, 6 records – 0 80, 7 records – 0 82, and 8 records – 0 84 As the number of records increases, more confidence can be placed in the record as to the cow's real producing ability under a number of different environmental situations

Which records should be used in comparing cows—the first record, the selected record, the highest record, or all records? Good arguments can be presented for the use of each record It has been generally accepted that a dairyman can place more confidence in a cow's producing ability if lifetime production is known rather than any other record Furthermore, if cows are ranked or compared and culled from a herd on their "Most Probable Producing Ability," faster genetic improvement will be made than when compared by the other methods indicated

Inheritance of Quantitative Characters The quantitative characters of dairy cattle are governed by many genes acting and inter-

acting in additive, dominant, epistatic, and other manners. Inheritance of these characters is described by a mathematical expression, "heritability." Heritability is an estimate of the additive part of the proportion of the differences between cows for a particular character that is the result of differences in their genic make-up. Another way of expressing heritability is to say that it is a convenient method for estimating the percentage of the *genetic differences which are transmissible from one* generation to another within a herd under average environment conditions. Heritability estimates are calculated by measuring the likeness between cows of different degrees of relationship (dam—daughter, etc.). High heritability characters are those in which the existent differences observed between cows are genetic (red, white, and roan color in Shorthorn cattle). Low heritability characters are those for which the observed differences are due mainly to environmental or nongenetic influences (milk production, etc.).

Heritability estimates for single butterfat records, singe lactation fat percentage, single lactation records, and single type classification are approximately 0.20, 0.50, 0.20, and 0.30 respectively. In other words, these estimates state that between daughters and their dams (when the daughters are all sired by one bull) the similarity on the average for the additive genetic proportion is 20 per cent when these comparisons are made on single lactation records. The estimates of heritability vary for the different characters but are fairly uniform from breed to breed and from different sections of the country, providing large numbers of cows were used in analysis. If the conditions in a herd were not characteristic of the average situation, then the estimates would not be completely accurate. Definite systems of mating (inbreeding, crossbreeding, crossing inbred lines), severe selection practices, and/or radically different feeding and management conditions might alter the influence of heredity and environment on a character; thus the heritability estimate would be altered. Nevertheless average heritability estimates seem to be useful in planning a breeding program. If the heritability estimate of a trait is high more emphasis should be placed on the individual cow's merit, while for traits with low heritability estimates, relatively more emphasis should be placed on the merit of the progeny and ancestors.

These heritability estimates can be combined with repeatability figures to predict the "Breeding Value" of a cow One half of the difference in breeding value of two cows would be the greater amount of production expected from the progeny of the better cow compared with the production expected from the progeny from the lower cow Calculating the breeding value of a cow is essentially the same as 'Most Probable Producing Ability" except that the heritability estimate replaces the repeatability estimate in the numerator of the expression $\frac{nh}{1 + (n - 1)r}$ n is the number of records, h is the heritability estimate and r is the repeatability figure When only heritability is estimated the expression is replaced by h The "Breeding Value" equation is as follows

$$\text{Breeding Value} = \text{Herd Ave} + \left[\frac{nh}{1 + (n - 1)r} \times (\text{Cow's Ave} - \text{Herd Ave}) \right]$$

Refinements in methods of comparing cows and predicting their future progeny's production is the goal of all dairymen Record analysis combined with good judgment in evaluating environmental conditions is essential for herd improvement

Herd Averages The most common herd average is the so-called D H I A average This herd average is the average production of all cows in the herd for a certain twelve-month period Cows may have freshened and been sold after two months Other lactating cows may have been purchased and entered the herd Occasionally the conception rate in a herd is lower than normal Disease outbreaks occur which materially reduce the herd average Feeding conditions vary markedly from year to year and sometimes within the same year In other words the D H I A average represents more of a management evaluation than it does the genetic potential of a herd

A 2×-305-M E herd average calculated from all records that were completed during the past year would de-emphasize the management effects and reflect more of the genetic potential A comparison of cows based on their 2×-305-M E average to date would be helpful in culling Further ranking of cows in the herd on the basis of their 'Most Probable Producing Ability" and 'Breeding Value"

would provide an even better screening process for culling cows and for selection of cows from which to save sons.

The Pedigree. One meaning of the word "pedigree" is ancestry or lineage, and in this sense all animals have pedigrees. As used in animal breeding, a pedigree is a list or table showing the ancestors of the animal in question and their relationship. For convenience the pedigree is generally put in a graphic form—usually the bracket form as illustrated by Fig. 42. In this form of pedigree the name of the sire is placed at the top of each bracket and the dam at the bottom. In this pedigree of the Jersey bull, Advancer Gem Commando, each bracket has a name and registration number on it. The term "pedigree" really includes all records of all ancestors, breed association production records (Advanced Registry and Herd Improvement Registry), type classification records, and D H.I.A. records. Also included in the pedigree are the records of the progeny of the cows and of the sires.

The most common kind of sire progeny report is called the "bull proof," but the "daughter average" is also frequently used. The bull proof has four variations. A sire which is used naturally and has 5 to 9 unselected daughters with production records which can be compared to their dam's records is designated as a Preliminary Natural Proved Sire. When the number of daughter and dam comparisons reaches 10 or more, a sire then is designated as an Official Natural Proved Sire. A sire which has 10 to 24 artificially bred daughters with production records which can be compared to their dams is termed a Preliminary ABA Proved Sire. When the number of daughter and dam comparisons total 25 or more, a sire is then designated as an Official ABA Proved Sire. The sire-proving work is a co-operation program between the dairyman, the tester, the state D.H.I.A. agent, the Cooperative Agricultural Extension Service, and the D.H.I.A. Section of the Dairy Husbandry Research Branch of the USDA.

Gene Frequency. The proportion of gametes (sperms and eggs) which contains a particular gene is called gene frequency. The frequency of occurrence of a particular gene in the population depends upon the genotype of the cattle selected to become the parents. In cattle heterozygous (Aa) for a particular trait, it can be

Advancer Gem Commando 475931 (L)
Superior Sire
USDA Proof

	Recs			
21 daus	30	0324M	5.6%	522F
9 daus	11	10331	5.6	581
9 dams	33	8844	5.2	403
(8-8.9)		+1487	+.4	+118

16 daus ave (305-2×-M.I.)
10176M-5.6%-565I
17 daus class ave 85.74%

Favorito Commando 457631 (E)
Senior Superior Sire
USDA Proof

32 daus	39 rec	10028M	5.5%	551I
13 daus	16 rec	9788M	5.4	531
13 dams	17 rec	10027	5.3	531
Diff (7-8.8)		−239	+.1	0

41 daus ave (305.2×-M.E.)
10527M-5.5% 580I
59 daus class ave 88.94%

Brampton World's Records 101251
CJCC* (VG)
Superior Sire
41 daus ave 10187M-5.3%-538F
19 daus class ave 87.40%

Brampton Lady Basilua 88733 CJCC* (E)
8 rec ave (305.2×-M.E.)
10636M 6.5%-688I

* *Canadian Jersey Cattle Club*

Advancer Marlu Gem 1147059 (VG)

2.0	305	3×	10162M	5.3%	536I	10712M	564I
3-1	305	3×	11027	4.8	559	11267	541
4.5	305	3×	12119	5.3	658	11203	595
5.5	305	3×	15486	5.3	819	13607	719
6.6	305	3×	14106	5.4	776	12612	675
7-8	305	3×	14810	5.3	784	11175	600

6 recs ave 11823M-5.2% 617F
(305-2×-M.E.)

Wonderful Advancer 367164 (E)
Senior Superior Sire
USDA Proof

14 daus	11 rec	8847M	5.1%	439F
8 daus	8 rec	8326	5.0	415
8 dams	16 rec	7633	5.5	421
		+693	−.5	−6

Bravo Nice Gem 1105068 (E)
8 recs ave (305.2×-M.E.)
11315M 5.0% 563I
6 daus ave 10174M 5.2%-528F

FIG. 42 Pedigree of Advancer Gem Commando, Reg No 475931, a Jersey bull. The name of the sire is at the *top*, that of the dam at the bottom of the bracket. USDA proofs, classification records, individual and average records of cows are shown to indicate the type of information usually desired.

said that the frequency of A is 0.5 and for a is 0.5. The total of these frequencies is unity or 100 per cent. If two heterozygous animals were mated then three genotypes would result—one AA, two Aa, one aa. If each of the genotypes were crossed with each other at random the gene frequency would remain at 0.5 for each gene (A and a) as shown by the following illustration.

Six Genotypic Combinations

MATING GENOTYPES	GENE FREQUENCY A	GENE FREQUENCY a	RATIO OF DOMINANT TO RECESSIVE PHENOTYPES IN OFFSPRING
1. AA × AA	1.0	0.0	all:none
2. AA × Aa	0.75	0.25	all:none
3. AA × aa	0.50	0.50	all:none
4. Aa × Aa	0.50	0.50	3:1
5. Aa × aa	0.25	0.75	1:1
6. aa × aa	0.0	1.0	none:all
Average	0.50	0.50	

If all genotypes were distinguishable then it would possible by selected mating to alter the 0.5 of A to 0.5 of a ratio. AA cows bred to AA sires would produce only AA offspring, thus ridding cattle of the a gene. This situation undoubtedly exists for many characters of our breeds of dairy cattle. The mating of homozygous recessive (aa) cattle would eliminate all the A genes. The horned condition in cattle is primarily governed by the recessive gene, while the polled condition is dominant. Probably in the evolution of our cattle those with horns could survive, thus the frequency of occurrence of genes for horns is found in most cattle. Numerous other examples illustrate the significance of gene frequencies and show that cattle improvement is basically a matter of controlling the frequency of the genes for the desirable traits which dairymen wish to perpetuate for efficient economical milk production.

Relationship. In order properly to select animals for a breeding herd and plan the matings of the selected animals it is important to know the relationship or probable genetic likeness of them. Since a sample half of the inheritance of a parent is transmitted to its off-

spring, the relationship between the parent and offspring is 50 per cent An individual animal is composed of 50 per cent from its sire and 50 per cent from its dam Since large numbers of genes are transmitted, both qualitative and quantitative characters are concerned Half brother-sisters are 25 per cent related Full brother-sisters are 50 per cent related

Random Breeding A truly random breeding system of mating should include all possible matings without any outside influences, such as selection of parents through natural or artificial means This cannot happen because dairymen do select parents for the future generations A system of breeding in which the mates have the same degree of relationship to each other as the cattle in the breed as a whole is known as random breeding

Many dairymen do not wish to follow any particular blood line and use bulls which are less closely related to each other than the average of the breed This is defined as outcrossing Herds can make considerable progress with this system of mating If dairymen have definite standards toward which they are selecting, a uniform herd with desirable characters can be developed This latter type of mating system is called assortative mating

In general, this is the kind of a mating system which results from using artificial breeding The use of a succession of high and well-proved sires should increase the homozygosity for high milk production by altering the gene frequencies responsible for it

Inbreeding Inbreeding is the mating of individuals which are more closely related than the average relationship within the breed or population Close breeding is the term applied to the practice of mating closely related individuals such as brother to sister, sire to daughter, or son to dam To generalize a bit, we may say that an individual is inbred when its parents show 50 per cent or more common ancestry in their pedigrees While the term is used by geneticists, biologists, and practical breeders, it might be well to state that nothing so extreme as the inbreeding of laboratory animals and plants by mating full brother and sister for generation after generation has ever been attempted in the realm of practical animal breeding Fig 43 shows inbreeding

Rainbow Captain Bold 38th
1104224

Sire: Rainbow Captain Bold 822580 (VG)
Silver Medal Production Sire
HIR Proof

65 daus	15080M	3 71%	559F
60 daus	15250	3 70	564
60 dams	13160	3 56	479
	+1700	+ 14	+85

Empire Ormsby Marathon 660180 (VG)
HIR Proof

14 daus	12320M	3 69%	455F
10 daus	11380	3 66	417
10 dams	11360	3 38	384
	+20	+ 28	+33

Rainbow Bess Rose 1447882 (E)

			Actual			305 2×	M F	
7-2	305	2×	15404	3 6	449	13864M	503F	2 daus 10
8 8	365	2×	20276	3 6	739	18248	665	recs ave
9 9	330	2×	13639	3 5	484	13093	465	14550M-3 5%-
10 9	305	2×	19109	3 1	593	17771	551	510F (M E)
12 1	365	2×	16523	3 3	541	15697	514	
13 9	365	2×	11488	3 4	387	10914	368	
15 1	301	2×	13530	3 3	452	13124	438	

7 recs ave 14673M 3 4% 501F (305 2×-M E)

Dam: Rainbow Bess Rose 2nd 2160920 (VG)

			Actual			305-2×	M F
2 5	365	2×	14416	3 7	526	16290M	594F
3-8	365	2×	15170	4 1	615	15018	609
4 9	305	2×	15207	3 6	540	14447	513
6-3	365	2×	19667	3 9	767	17611	678
8-2	365	2×	21278	3 8	808	19150	727

5 recs ave 16503 3 8%-624

Rainbow Captain Bold 822580 (VG)
(see above)

Rainbow Bess Rose 1447882 (E)
(see above)

FIG. 47 Pedigree of an inbred Holstein bull, Rainbow Captain Bold 38th, Reg No 1104224 The sire and the maternal grandsire are the same Also, the paternal and maternal granddam are the same This is very close inbreeding

Advantages of inbreeding Some of the advantages of inbreeding have already been referred to in the discussion of the early development of Shorthorn cattle The primary effect of inbreeding is to intensify or fix hereditary qualities and thereby bring about homozygosity for certain characters It is not surprising, therefore, that the fixation of type in the early establishment of any breed is best accomplished by inbreeding Once this purity of germinal make-up is accomplished its transmission to offspring is almost certain, as in the case of the black and white color of Holsteins

Ill effects of inbreeding The same mechanism which makes inbreeding so successful in fixing desired characters operates to bring about the concentration of factors which may lead to disaster Lethals and other defects are quickly observed as a result of inbreeding Animals can be catalogued for these traits and selections made from noncarriers so as to perpetuate the herd The things most feared in this connection are decreased fertility and vigor Fertility is a character of prime importance to breeders of domestic animals, and any successful demonstration of the advantageous use of inbreeding is apt to be closely scrutinized by the practical breeder for evidences of lowered vitality and lessened fertility in the offspring Perhaps the best known case of the ill effects following close inbreeding is found in the high percentage of nonbreeders among the Bates' Duchess Shorthorns Investigation shows that this strain carried barrenness very early in the family history and there was no greater intensification of this defect than would follow in any other character where inbreeding is employed Mumford[10] reports cases of long-continued inbreeding of dogs and of Berkshire hogs without loss of vigor or fertility Wright[11] observed the results of maintaining families of guinea pigs wholly by matings of brother and sister Some families declined in vigor, but one had reached the twentieth generation with no evident loss of vigor He concludes that inbreeding is merely likely to lead to decline in vigor but does not necessarily do so Intensive inbreeding is now commonly practiced in rat colonies maintained for nutrition and other experimental purposes No loss of

[10] Mumford *The Breeding of Animals* p. 288 The Macmillan Co New York N Y (1917)

[11] U S D A Bulletin 905 p 40 (1920)

vigor is found to result when careful selection is practiced. Many lines of such inbred rats have been developed at the Minnesota Experiment Station, one line having more than fifty generations of continuous brother-sister mating. There are some herds of dairy cattle that apparently have been able to withstand inbreeding. In experimental inbred herds of dairy cattle a number of ill effects have been observed.[12,13,14] Inbreeding had only a slightly adverse effect on fertility, but increased calf mortality, and reduced birth weights, mature size, and milk butterfat production.

Selection and inbreeding. After long and continued inbreeding of fruit flies, Castle and his associates concluded that inbreeding unaccompanied by selection for high productiveness results in maintaining the original fertility of the race. Careful selection of individuals from large litters of white rats has resulted in increasing the average size of litters by inbreeding.

With all the evidence at hand it can be safely concluded that danger lurks in the use of inbreeding by anyone but a breeder who is capable of selecting his breeding animals not alone for the presence of the desirable factors he is seeking to concentrate, but as well for the absence of those things which will in the end lower vitality or lessen fertility. It is the most rapid means of advancement in breeding, but is a dangerous tool in the hands of any but those trained to its use.

Line Breeding. The mating of animals related in a lesser degree than that described as inbreeding is known as line breeding. Where the common ancestry of the parents ranges from *25 to 50 per cent* we have what is popularly called line breeding. This system is said to possess all the advantages of inbreeding with a greatly lessened tendency toward production of defectives.

Line breeding is without doubt the most popular system used by breeders of purebreds. Much progress in cattle breeding is traceable to line breeding, as many men have held aloof from inbreeding for fear of disaster; but they have recognized the principle of concentration of desirable characters through the use of related animals and hence have resorted to line breeding. Results this way may come

[12] U.S.D.A. Technical Bulletin 927 (1946).
[13] U.S.D.A. Technical Bulletin 990 (1949).
[14] Nelson and Lush, *Journal of Dairy Science*, 33:3 (1950).

Avon View Rosie's Tamarind 110550

Royal's Tamarind of Lee's Hill 76059
USDA Proof 5-5 53
5 daus 0 rec 11 305M 4 3% 1951
5 dams 10 rec 9 371 4 1 313
Diff (5-4 5) +1 021 + 2 +152

7 classified daus (1E 1VG 3GP 2G)

Judi's Bridge Rosie 158100 (1)

		Actual			305 2X-M E	
2	2X 305	11832M	4 09%	4841	14700M	051
1	Not tested					
*4	2X 305	15056	4 00	615	16110	670
**5 4	2X 305	10717	4 50	703	17210	756

3 recs ave 10130M-4 2%-0871

*4th on Honor Roll
**5th on Honor Roll

Jane's Royal of Vernon 28504 (1)
USDA Proof
12 daus 78 rec 12881M 4 2% 5381
5 daus 8 rec 11305 4 0 457
5 dams 0 rec 13011 3 8 513
Diff (1-4-1) −2570 + 2 −76

Marin la Jane of Lee's Hill 90074 (1)

		Actual			305 2X-M E	
*5	3X 305	15280M	4 75%	720F	13110M	621F
5-11	3X 305	15121	4 01	710	13202	615
8-1	3X 305	18235	4 08	553	12916	606
11-1	3X 305	21261	4 61	1117	18023	806

4 recs ave 14508M-4 7% 6781 (305 2X-M E)

*8th on Honor Roll

Colonel Harry of J B 18072 (1)
USDA Proof
114 daus 318 rec 11734M 4 4% 511I
65 daus 85 rec 11881 4 3 511
65 dams 219 rec 11518 4 1 478
Diff (35 53-10) +303 + 2 +36

84 classified daus (13P, 38VG, 20GP, 4G)

Royal's Rosie of J B 02103 (VG)

		Actual			305 2X-M E	
2-2	2X 303	7120M	4 7%	3151	10166M	1041
3-3	3X 305	12880	4 5	581	13266	509
4-1	3X 305	15210	4 5	604	13840	632
7 6	2X 305	10581	4 0	761	10551	703
9	2X 305	15471	4 6	709	15474	710

7 recs ave 13518M-4 5%-6091

FIG 41 Pedigree of linebred Brown Swiss bull, Avon View Rosie's Tamarind Reg No 110550

more slowly, as there is constant introduction of hereditary elements from slightly different lines of descent. But while this may retard the purifying process for desirable characters, it also serves to neutralize defective elements, and in this we may find the cause for the popularity of line breeding, as most men would prefer to progress slowly in animal breeding rather than to follow shortcuts where possible disaster lurks.

One danger which is ever present in line breeding is the possibility of selection entirely by pedigree, and the abandonment of individual selection. While the pedigree may picture an ideal combination of ancestry, any system of progressive breeding must be based on the mating of superior individuals measured by their own performance and the performance of their progeny

Crossbreeding. Crossbreeding is the mating of animals belonging to different breeds. Many cattle are the result of crossing of grades which resemble one breed or another. Very few dairymen have crossed purebred breeds. It does happen when the market appears to be more favorable toward the milk produced from a particular breed. In the past few years many of the grade herds which contained a rather high genetic proportion of the high fat breeds have been using Holstein sires. Thus a tendency toward crossbreeding has been under way.

Hybrid vigor or heterosis[15] has been defined as "The superiority over the better parent that is exhibited by the progeny." Hybridization has been considered to have a stimulating influence on the behavior and development of various plants and animals. The circumstantial evidence for hybrid vigor has been demonstrated to be a reality in corn, swine, poultry, sheep, and beef cattle.

A few dairy crossbreeding experiments have been conducted. The Dairy Husbandry Branch of the U.S D.A. in 1939 initiated the most extensive study involving two and three breed crosses of Holsteins, Jerseys, Guernseys, and Red Danes.[16] This project was started to provide information for dairymen who might decide to use crossbreeding as a means of producing better replacements for their

[15] *Journal of Animal Science*, 1:90 (1942).
[16] U.S D.A. Technical Bulletin 1074 (Feb 1954).

milking herds The foundation cows (55 cows), the two breed crosses (55 cows), the three breed crosses (58 cows), and the progeny of the three breeds produced on mature equivalent basis 13,799 – 594, 17,811 – 799, 18,240 – 801, 17,764 – 800 pounds of milk and butterfat respectively When production-proved sires were used a large increase in milk and butterfat production was shown in the first cross with slight further increases in the following generations Additional investigations are being made to determine if the crossing breed results will be substantiated

It would appear that if heterosis can be used to advantage in raising the level of production, it should be recognized Breed crossing is not recommended for owners of purebred cattle The responsibility of purebred breeders is to maintain pure stocks and develop them in such a fashion that improvement can be made These cattle have been, and still are, the fundamental core for breed improvement Registered cattle are only about 6 to 7 per cent of the national dairy herd Therefore, the preferred method for breeding the grade or commercial dairy cattle becomes an important consideration If crossbreeding for these grade or commercial herds offers some real advantages, the merits and/or faults should be known More research work on crossbreeding is needed

The Importance of Selection Regardless of the system of mating chosen, the accuracy in selection is most important to accomplish the standards desired by dairymen Selection is aimed at changing the frequency genes responsible for the characters desired Practically, it means different rates of reproduction for certain cattle within a herd or breed If low-producing poor-type cows are culled from the herd, while the better ones are allowed to reproduce, some progress should be made

The selection of dairy cattle can be made on the basis of own performance of the individual cow, of evaluating the ancestry of individual cows and by studying the performance of the progeny of cows and sires It is of course best to use all possible methods of selection Indexes have been formulated in attempts to weight the contribution from each of the methods for an accurate appraisal of the animal s phenotypic and genotypic makeup Refinements should be made in

the near future since many more records supported by environmental data are becoming available for analysis. An increase in number of cows entered on test would improve the dairyman's position for improved selection methods. Continued sire proving and greater use of these good bulls would help change the entire dairy cow population for higher production.

The selection methods to be used depend upon the nature of the trait being considered. Highly heritable characters could be selected for own performance or appearance. This includes most of the qualitative characters. Characters with low heritability will be more successfully selected for by using not only own performance and/or appearance but also ancestral evaluation and progeny appraisal.

Sires to be used should be ones about which the greatest information is available. This means accurate and sound proved sires. There is some question just how to define such sires, but progress is being made. The use of proved sires has been greatly extended by the artificial breeding program described in Chapter XIX. Bull associations, that is, four or five dairymen agreeing to sample, retain, and rotate the best sires among themselves, have been growing in number, but it represents a very small percentage of the total. Purebred breeders are working more closely together since they realize the real necessity of numbers of cattle for accurate evaluation of the breeding value of cows and sires.

When proved sires are used, the generation interval is lengthened considerably. The average interval between generations is about five years and if sires are retained longer the interval will be further lengthened. If considerable progress is made during each generation, then it would be advantageous to shorten the generation interval as much as possible. The use of young sires selected by the best methods available might give as much and possibly more progress than the use of proved sires. This is a debatable question, and until the issue is settled, proved sires appear to be the best bet. Through artificial breeding proved sires can be most effectively used, while young bulls could be practically handled on farms. A fair percentage of young bulls needs to be sampled and proved to allow rigid culling of sires for the ABA studs. It is highly recommended to use proved bulls if

they are available and fit into a dairyman's program The second best procedure is to use young bulls selected in accordance with the best procedures

Why So Few Purebred Bulls? Innumerable instances are on record and countless stories have been written of the rapid improvement in dairy cattle through the use of purebred bulls, and the question naturally arises why so few purebred bulls are in use Records in purebred cattle associations show that less than one fourth as many males as females are registered This is due partly to closer culling of bulls, and to the artificial breeding program, but if all the purebred bulls dropped were kept, there would not be enough to replace the scrub sires now in common use One fact that contributes to this condition is the small size of many herds kept by dairy farmers, but this can be overcome by the organization of bull associations, by use of artificial insemination, or the co-operative purchase of a good bull by two or more farmers in one neighborhood Another factor entering into the problem is the poor salesmanship on the part of breeders of purebred stock Many of them ignore this large field for disposing of their bulls to the many ordinary dairy farmers, and limit their selling efforts to herds of pedigreed stock While it is true that better prices are usually realized from the latter class of buyers, it is also true that their demands are more exacting and their number greatly limited Every good purebred herd has a surplus of males that could well be placed in grade herds at a fair profit to the breeder and to the great benefit of the dairy business

Summary. As a summary to this chapter on cattle breeding the following recommendations are made to the breeder of purebred dairy cattle

1 Use proved sires whenever possible as the progress of years may all be lost by bringing an untried bull into the herd Young bulls should be used sparingly until their first daughters come into production
2. Cull the female herd carefully and constantly in order to eliminate undesirable individuals and prevent the perpetuation of their undesirable qualities through offspring
3 Test the cows and heifers and classify for type in order to determine what progress is being made and to measure the transmitting ability of both the herd sire and females

For the dairy farmer with a grade or scrub herd it is recommended that he:

1. Join a dairy herd improvement association in order to determine the truth about the productive ability of each member of the herd.
2. Cull the female herd according to the results secured by testing.
3. Send the scrub sire to the butcher and replace him by using artificial breeding, or by the second best method of using sires co-operatively in a bull association, or by buying a purebred sire selected by the best methods available. See your county agent or vocational agricultural teacher for help.

CHAPTER XVI

Calf Feeding and Raising

IMPORTANCE OF CALF RAISING

Economic Considerations According to the *Agricultural Statistics* for 1953 there were approximately 23,996,000 cows and heifers two years and older being used and raised for dairy purposes in the United States Dairy cows under present conditions of management in the United States average less than five lactations after coming into milk and must be replaced by the time they are from seven to eight years old On this basis more than 5,000,000 heifer calves must be raised each year to maintain the present dairy cow population

The ultimate prospect of a heifer calf entering the herd as a regular breeding and milking cow is dependent on several conditions, including live birth, calfhood mortality, later death or failure to conceive and to produce satisfactorily after calving

Many studies of this part of dairy herd replacements have been made at several of the agricultural experiment stations These studies have made a large amount of data available on this important phase of dairy herd development and management [1 2 3] However, probably no one single area of herd development on the average dairy farm has received so little study and scientific care as that of calf raising It is an important factor in the success of any dairy herd and an important factor in the final cost of milk production

[1] Weaver Harwood and Smiley Michigan Experimental Station Quarterly Bulletin 32 (1949)
[2] Davis, Nebraska Experiment Station Bulletin 411 (1952)
[3] Becker and Arnold Florida Experiment Station Bulletin 520 (1953) Also Bulletin 540 (1954)

Importance of Maintaining the Herd. The success of the dairy farmer depends to no slight extent upon the careful rearing of the calves. The careful dairyman should see in every heifer calf the possibility of a cow that will not only replace a discarded member of his herd, but help to raise the average production. By proper care in the choice of the sire, and by careful attention to the rearing of the calves, the dairyman who is compelled to start with a herd of ordinary quality may, within a few years, raise the average production of his herd to a marked extent. On the other hand, carelessness in breeding and in calf raising is bound to result disastrously to a herd or, at least, to keep it at a standstill as far as improvement is concerned.

Disadvantage in Replacement Buying. One of the common mistakes made in the localities where whole milk is sold for market purposes or to condenseries or cheese factories is the failure to raise any calves. In this case the milk producer depends upon buying cows to replace those discarded from his herd. The excuse for this practice is that the cost of raising cows is too great. Under such a system a dairyman will almost invariably produce milk year after year without improving the standard of his herd in the least. When more cows are required, they are purchased from a shipper or dealer, and without any information available regarding the merits of the animals beyond what can be determined from appearance. The dairy cows placed on the market through such channels are almost certain to be of very ordinary grade, since a cow whose value as a milk producer is known is not offered for sale at the market price. The practice of replacing cows by purchase also involves the danger of introducing such diseases as tuberculosis, contagious abortion, vibrio foetus, and mastitis, which may result in the destruction of the entire herd.

In a few localities the practice is even worse, inasmuch as the cows are purchased when about to calve, are milked but a single milking period, and are then fattened when the milk flow slackens, and sold for beef. Many cases are known of herds in which the discarded cows were replaced by purchase rather than by raising calves, maintained for over twenty years without the slightest increase in the average production. The only means by which the average quality of dairy herds in the hands of practical dairymen can be materially

improved is by the raising of their own cows from carefully selected calves sired by proved purebred sires and from only the best cows of the herd Many surveys show that home raised replacements have a longer productive tenture, lower average annual depreciation, and a higher average yearly production per animal

EARLY CARE

Birth Weight of Calves. Table 24 gives data on the weight of calves at birth

Table 24 Birth Weight of Calves

BREED	MALES		FEMALES		AV BOTH SEXES		WEIGHT OF CALF IN PROPORTION TO WEIGHT OF DAM PER CENT
	No	Lbs	No	Lbs	No	Lbs	
Jersey	102	58	94	53	253	55	6 3
Holstein	69	93	85	88	229	89	7 8
Guernsey					57	71	7 1
Ayrshire	27	73	26	65	80	72	7 3
Brown Swiss					5	100	8 9
Dairy Shorthorn	11	74	19	73	30	73	6 0

This table shows that the males average heavier than the females at birth The Brown Swiss and the Holstein calves are the largest at birth, and are also heavier in proportion to the weight of their dams.

About three out of five calves come within 10 per cent of the average weight Breed is the most important factor influencing the size The maturity of the cow also has some effect as shown in Table 25.

The size and vigor of the calf at birth are not influenced as much as might be expected by the previous feeding and condition of the dam The reproductive function is so strong that in case of insufficient feed the fetus draws on the mother's body, and it is the mother that suffers more from the deficiency in nourishment On the other hand, when a cow is excessively fat, the calf is more often somewhat undersized

Table 25 Relation of Order of Calving, Sex, and Gestation Lengths on Birth Weights of Jersey Calves

Order of Calving	MALE CALVES				FEMALE CALVES			
	Number	Average Gestation	Birth Weights		Number	Average Gestation	Birth Weights	
			Range	Average			Range	Average
		Days	Pounds	Pounds		Days	Pounds	Pounds
1st	125	276.4	28 to 66	49.3	112	275.6	20 to 73	47.5
2d	92	278.4	27 to 70	57.3	92	276.3	36 to 72	53.4
3d	60	278.7	40 to 80	57.3	75	277.2	40 to 69	54.7
4th	49	277.5	40 to 78	56.9	49	277.2	37 to 68	53.9
5th	33	278.0	43 to 80	58.8	33	277.1	42 to 67	54.0
6th	26	280.4	46 to 75	54.7	18	276.2	46 to 64	55.1
7th	18	277.3	45 to 78	55.4	11	277.4	34 to 65	54.4
8th	7	280.0	50 to 70	59.9	11	276.4	38 to 64	50.6
9th	7	284.7	48 to 70	62.3	4	278.3	44 to 60	51.0
10th	2	275.0	60 to 64	62.0	4	276.8	46 to 55	50.0
11th	1	276.0	—	50.0	1	276.0	—	54.0
12th	1	280.0	—	48.0	—	—	—	—
13th	—	—	—	—	1	277.0	—	60.0
Total or Ave	421	277.9	—	55.2	411	276.5	—	51.9

* Arnold and Becker, Florida Experiment Station Bulletin 529 (1953)

Raising Calves by Hand The dairy calf, is almost always reared by hand because, as a rule, the milk of the dairy cow is worth much more than the calf The question of calf raising is naturally divided into two different considerations One deals with the raising of calves where milk is separated at the farm and cream is sold to the creamery, or where skim milk is returned from the creamery in unlimited amounts for calf feeding The second consideration is concerned with methods of raising calves where whole milk is sold to the condensery, to the cheese factory, or for market milk use In this case no skim milk is available and even the amount of whole milk is very limited and much too high priced to be used in unlimited amounts for calf feeding The calf must be fed whole milk only for as short a time as possible, as such milk makes an expensive ration, or else the calf to be raised must be given some suitable substitute for milk

Attention at Calving Time The birth of a calf is a critical period for the calf as well as for the mother, and for this reason the dairyman who expects to be successful in raising good calves must be alert in his attention to the dam of the unborn calf and must stand ready to give his full attention to the calf after birth

The cow should be placed in a clean, well bedded maternity pen well in advance of the expected calving time Usually a cow will not need assistance in calving, but the dairyman should be near at hand to render assistance if needed, or, if the calving is abnormal, to see that the services of a veterinarian are secured in time

When the calf is born, the first act of the dairyman should be to see that the calf starts breathing Sometimes mucus or phlegm must be removed from the mouth or nostrils before breathing can start As soon as the calf breathes, the navel cord should be stripped out of any clotted blood and disinfected as a precaution against disease Painting with iodine is a common practice

Before the calf stands to suck, the cow s udder and teats should be washed with chlorine solution This is a guard against infection

Taking the Calf from Its Mother There is great difference in opinion and practice regarding beginning of hand feeding Some take the calf away from its mother at once without allowing it to nurse at all Others prefer to let it nurse once, and some allow it to remain

with the cow three or four days, or until the fever is out of the udder and the milk is fit for use in the dairy. It probably makes very little difference as to this point; but it is a fact easily established that the earlier the calf is taken from the cow, the easier it will be to teach it to drink. The calf that has never nursed is easily taught to take the milk from a pail, while a calf a week or a month old is often a dif-

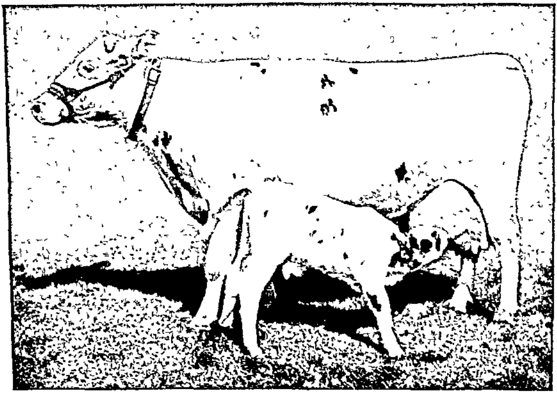

FIG. 45. Colostrum or first milk is important in calf feeding. This calf was allowed to nurse its dam for the first 36 hours, later being changed to hand feeding with whole milk and later to skim milk and calf feeds.

ficult subject to teach. A safe practice and one generally followed is to take the calf away from its dam on the third day. When the udder is caked, it is best to leave the calf with her until this condition is removed.

Importance of Colostrum. One point that must be kept in mind is that at first the milk from the mother should always be given the calf, and not milk from some other cow. The first milk, or colostrum, given by a cow is especially suited to the requirements of a young

calf The usual explanation has been that the colostrum acts as a physic and stimulates the digestive organs Recently it has been found by one investigator that two proteins of the blood which are absent in the newborn are present following the ingestion of colostrum

Early investigations by Little and Smith[4] further emphasize the importance of the colostrum milk to the newborn calf and give a new explanation of its value In their experiments, all of ten calves allowed to take colostrum survived, while eight out of twelve which did not get colostrum died, and one other did not thrive Their explanation is that calves deprived of the colostrum lack something which permits intestinal bacteria to invade the body and multiply in the various organs In most cases a rapidly fatal septicemia is the result The calves which do survive are able to resist the invading bacteria and develop into normal animals, or in some cases the joints or kidneys may be affected According to the view of the investigators, the function of the colostrum is to serve as a protection against miscellaneous bacteria which are harmless when the protective functions of the calf have begun to operate Colostrum also has a high vitamin A content

Teaching the Calf to Drink Under natural conditions the calf takes its milk frequently and in small quantities The calf's stomach at this time is not suited for holding a large amount, and an excessive amount always results in indigestion or scours For this reason, it is well to feed the young animal three times daily for a week or two It is an easy matter to teach a calf to drink milk from a pail Omit the first regular feeding period after the calf is removed from its dam, and it will be eager and hungry Then offer it a small amount of milk in a pail and gently lower its head until the muzzle is in the milk This is done by allowing the calf to suck the feeder's fingers, drawing its head down into the bucket, and withdrawing the fingers when it tastes the milk.

The Nipple Pail The nipple pail for calf feeding has been perfected in recent years and has come into great favor with many dairymen This pail has a hard rubber nipple that can be detached Within the nipple is a valve that restricts the stream of milk the calf can obtain at each swallow The pail is secured in the pen at about the

[4] *Journal of American Medicine* 36 181–198 (1922)

elevation of the calf's head and the calf readily uses it, but cannot drink too fast, which is a common fault of ordinary pail feeding.

Amount of Milk to Feed. For the first week, 4 or 5 quarts or about 8 or 10 pounds per day, is all the largest calf should be allowed to take. A small calf, such as a Jersey, does not need over six or eight pounds per day at the start. The second week, these amounts can be raised a pound or two, provided the calf has shown no sign

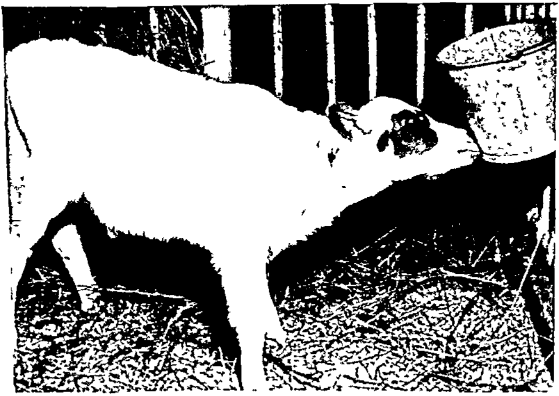

FIG. 46. Calves learn to drink milk quickly with the nipple pail This calf is two days old.

of indigestion and its appetite is good. As the calf grows older, somewhat more milk can be used, but at no time does it need over 16 or 18 pounds, or eight or nine quarts per day. It is safe and economical to feed as high as 20 pounds to a large calf if skim milk is plentiful. Overfeeding is undoubtedly one of the most common causes of inferior calves. It is a mistake to think that because the cream has been removed, the calf needs more of the skim milk, or because the calf is not doing well it is not getting enough milk, and to allow it to

gorge itself, which it will readily do if given an opportunity A good rule is always to keep the calf a little hungry Some provision must be made for making certain that each animal gets its share and no more Some drink twice as fast as others, and if fed together, one will be overfed and the other starved The plan sometimes used of feeding a bunch of calves together in a trough is very unsatisfactory for this reason, and should never be followed Success can be assured only by individual feeding

Temperature of the Milk Another precaution that should be taken is to have the milk warm and sweet when fed Nature furnishes the milk to the calf in this condition, and we must carefully imitate her here The digestion of a calf is quickly upset by feeding warm milk at one feeding and cold milk at another For the first few weeks the calf is especially sensitive to the temperature of its feed After it is three months or more old, the milk may be fed somewhat cooler, if care be taken to have it at the same temperature all the time Even then, however, the best results are secured when the milk is fed warm The temperature of the milk should be that of the blood, or approximately 100° F In this matter the feeder should exercise great care and not go by guess or by the feeling of the milk, but should actually use a thermometer often enough to know what blood heat feels like If a hand separator is used, the milk may possibly be fed while still warm enough if used immediately after separation, but it will usually be necessary to heat it artificially, if used for young calves during cold weather

RAISING CALVES ON SKIM MILK

It is well established that a calf can be raised on skim milk and be equally as good as one nursed by its mother or raised by hand on whole milk In localities where it is the practice to separate milk with a cream separator on the farm, this fact is well recognized, but in other regions it is virtually unknown Some persons have seen unhealthy, stunted, and undersized calves that have been fed on skim milk and think that all calves fed on skim milk are likely to be the same Such calves are only the unfortunate results of the owner's ignorance, carelessness, or poor handling The skim milk calf raised

according to modern methods differs little, if any, in size, thrift, or value from the same animals raised by the cow. The poor results which have so often followed the feeding of skim milk have been due to faulty methods and not to the fact that the cream or butterfat taken out of the milk was indispensable to the normal development of the calf.

Composition of Skim Milk. The following statement gives the average composition of whole milk and separator skim milk:

	WHOLE MILK	SKIM MILK
Water, per cent	87 10	90 50
Fat, per cent	3 90	10
Proteins, per cent	3 40	3 57
Sugar, per cent	4 75	4 95
Ash, per cent	75	78

It will be observed that the skim milk differs from the whole milk only in having most of the fat removed. The other constituents are slightly increased. The butterfat or cream is by no means the most valuable part of the milk for the calf. The fat does not serve primarily to support growth in the young animal, but to keep up the heat of the body and to supply fat for body tissue. Materials which serve these purposes can be supplied much cheaper in the form of carbohydrates in corn meal or other grain. Milk fat is one of the carriers of vitamin A, but fortunately the precursor of this essential substance is also present in the leafy portions of many forage plants and can be supplied to the animal in the roughage portion of the ration. The raising of the calf on skim milk is economical, because it is possible to make this substitution of a comparatively cheap grain for butterfat, which has a commercial value for human food out of proportion to its food value for a calf. The proteins of the milk are of special importance in relation to growth. The casein and albumin which make up the bulk of the protein are of especially high quality and more efficient for growth than proteins from grains. From the proteins are made muscles and bone, nerves, hair, and hoofs; and these proteins remain in the skim milk. The calf fed on skim milk is not generally so fat during the first six months of its life as the one nursed by the cow. It often has, however, rather a better development of bone and

muscle, and the difference between the two cannot be seen two weeks after weaning time At Storrs Experiment Station it was found that two calves fed on milk testing 3 27 per cent, one for 63 days and the other for 30 days, consumed 1 16 and 91 pounds of milk solids respectively for each pound of gain in weight, whereas two calves fed milk testing 5 1 per cent and 4 6 per cent for 53 and 30 days required 1 33 and 1 03 pounds of milk solids respectively for each pound

FIG 47 A Holstein calf six months old raised with a minimum amount of skim milk

gained The results clearly show larger daily gains on a smaller amount of solids per pound for the calves which received the milk containing the lower per cent of fat

Changing to Skim Milk For the first two or three weeks the calf should be fed part of its mother's milk However, in raising calves of those breeds producing a very rich milk, the calf will often thrive better if the whole milk given during the first two or three weeks be diluted with some skim milk Beginning at the age of two weeks, if the calf is doing well the ration may be gradually changed

to a skim-milk ration by putting in a small amount of skim milk at first, and gradually increasing the amount day by day until at the end of a week all the whole milk has been replaced.

Importance of Fresh Milk. In order to make a success of raising the calf, the condition of the milk must be uniformly good. One of the common causes of indigestion and its most pronounced symptom, scours, is the feeding of stale milk. As is well known, a variety of fermentations begin their activities in milk within a few hours, if the milk is not cooled to a very low temperature. Among these are some that act freely upon the proteins, and the by-products of such decomposition are especially dangerous. Under ordinary conditions the injurious fermentations are liable to develop, and practical experience has shown that it is difficult to get results that will satisfy the particular calf raiser when milk is held even twelve hours in an ordinary ice cooler and then warmed for feeding. The best results are obtained only by separating the milk at once after milking and feeding the skim milk immediately. The younger the calf, the more sensitive it is to the condition of the milk. Although it is possible to raise a calf on sour milk after it is well started—provided the milk is fed in the same condition every day—the results are not as satisfactory as with sweet milk. Otis compared buttermilk with sweet skim milk by feeding ten calves on each. Those receiving skim milk gained an average of 2.02 pounds per day for 126 days, while the group that was fed buttermilk averaged 1.79 pounds per day. The latter group had less trouble from indigestion than did those fed with sweet skim milk.

The Creamery and the Skim-Milk Calf. Patrons of creameries who deliver whole milk for separation and take back skim milk have often experienced difficulties in raising calves on this returned milk, especially in warm weather, when the milk sours on the return trip. Another grave danger incident to this practice is the introduction of disease into the herd, as the milk which the patron receives is part of a mixed lot from a number of farms. These troubles can only be avoided by thorough pasteurization of this skim milk at the creamery before it is taken back to the farm. Every creamery receiving whole milk should be equipped to handle skim milk in this

manner, and patrons should insist upon careful pasteurization as a safeguard against disease and calf troubles Heating to a temperature of 150° F and holding at that temperature for thirty minutes, or heating to 180° and then cooling, will render the milk safe for feeding purposes A better practice would be to install a separator on the farm and thereby have the milk sweet and fresh for feeding reduce the bulk of product to be hauled to the factory, and avoid disease hazards

The Farm Separator and the Skim Milk Calf Warm, sweet, skim milk, separated within a few minutes after being drawn from the cow, is in the best possible condition for the calf By following the practices of the most successful dairymen (which have been mentioned), there will be little trouble in raising as good calves as are raised in any other way The majority of those producing cream or butter for sale insist on some means of raising the calf satisfactorily, and the hand separator seems to fill the want better than any other system

Supplement with Skim Milk The practice of raising calves on skim milk, supplemented with mixtures of farm grown grains and legume hay, has been well established for a number of years, and the data available resulted from experiments conducted during the investigational period The figures shown in Table 26 afford an accurate record of the quantities of milk, grain, and hay used in successful trials

The following table shows that the calf can get along with as little as 73 pounds of whole milk, although generally 200 pounds or more are fed The skim milk varies as a rule between 2,000 and 3,000 pounds and, while calves can be reared without grain when skim milk is fed, it is customary to feed up to 150 pounds per animal during the first six months These figures vary according to the thrift of the animals and skill of the feeder, but satisfactory results can be had by feeding quantities within the limits shown in the table The calves receiving a larger amount of whole milk weigh heavier at the close of the milk-feeding period, but this difference gradually disappears during the next few months if all the animals are fed alike

Fall calves need from 300 to 600 pounds of hay the first six months, depending upon how much other feed is given Spring calves may be put on pasture, or they grow equally well if kept confined for the first three or four months and fed hay

Table 26 Feed Required for Skim Milk Calf the First 180 Days

	STORRS* EXP STA	STORRS† EXP STA	PURDUE‡ EXP STA	NEB § EXP STA	MISSOURI ¶ EXP STA
No animals	3	17	10	16	4
Length of period days	180	180	182	168	—
Whole milk lbs	73	155	131	242	367
Skim milk lbs	2 067	2 954	2 022	2 450	3 041
Hay lbs	277	477	456	80	81
Grain lbs	231	63	179	128	90
Pasture days	—	—	—	98	90
Weight at beginning lbs	75	62	62	68	73
Weight at end lbs	299	299	283	299	329
Average gain per day lbs	1 25	1 28	1 21	1 37	1 41

* White and Kuelling Storrs Experiment Station Bulletin 102, p 91 (1919)
† Beach Storrs Experiment Station Bulletin 28 (1904)
‡ Hunziker and Caldwell Purdue Experiment Station Bulletin 193 (1916)
§ Burnett and Smith Nebraska Experiment Station Bulletin 85 (1904)
¶ Unpublished data

RAISING CALVES WITHOUT SKIM MILK

Dairymen who sell their product as market milk, or to a cheese factory or condensery, are confronted with the problem of raising calves without skim milk, as the separation of a small quantity of milk for calf feeding involves additional labor cost and further complicates the marketing problem The use of whole milk entirely for raising young stock on these farms would make the cost of feeding calves prohibitive, as a calf would require 400 to 500 pounds a month for proper development, and at $3 per hundred pounds the calf would consume about $75 worth of milk during the first six months, or the ordinary milk-feeding period Under such conditions there is a strong temptation to veal or kill the calves, but the unsatisfactory results and dangers which follow the practice of replenishing the herd by purchases have already been pointed out

Three methods are suggested for successfully raising calves on

farms where whole milk is sold, and the purpose of each is to limit the use of milk to a minimum quantity The first is by using a so-called "milk substitute," either a commercial calf meal or home mixture fed as a gruel The second is the use of a small quantity of whole milk either by dilution or feeding it in conjunction with calf meal gruel The third is to use whole milk during the first six

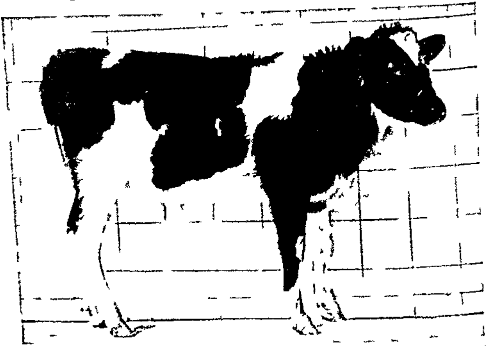

FIG. 48 Vitamins play an important part in calf raising This calf received vitamins A and D supplement along with skim milk feeding to prevent rickets and unsatisfactory gain.

or eight weeks to insure a good start in growth and then put the animal on a ration of grain and hay

Milk Substitutes Commercial and home mixed calf meals are being used extensively as satisfactory substitutes for milk in calf raising In making a mixture of feeds that will replace milk in the calf ration, the requirements are that the ingredients be easily and readily digested by the young animal, palatable, not too costly and of a chemical composition to correspond closely to that of milk These few requirements present some serious obstacles as the list of available feeds of a character adapted to the undeveloped digestive

organs of a young calf is decidedly limited. Some of the materials most commonly used are: finely ground corn, middling, oat flakes, red dog flour, rice flour, flaxseed meal, linseed meal, cocoanut meal, blood meal, and skim milk powder.

Proprietary Calf Meals. Proprietary calf meals sold under various names have been tested experimentally, and the consensus is that few of them give entirely satisfactory results as complete substitutes for milk in the calf ration. As supplements to milk, or when used to replace part of the milk, both the home mixed and the commercial calf meals have given fairly satisfactory results. Success in the use of calf meals has been found to depend mostly upon getting the calves well started on a milk diet, and continuing the use of milk in a limited way until the animal is able to eat and digest enough of the meal, grain, and hay to continue its growth satisfactorily. Early setbacks are hard to overcome.

Limitations of Milk Substitutes. A study of the list of feeding stuffs used in the so-called milk substitutes, from the standpoint of the newer knowledge of nutrition, suggests that the difficulty experienced in getting a satisfactory milk substitute also involves the question of vitamins, proteins of a suitable quality, and an adequate supply of mineral matter, especially calcium. More recently much attention has been devoted to the use of certain antibiotics, especially aureomycin, in the feeding of young calves, pigs, and chickens. The whole field of antibiotics and hormones is still very new and is given greater attention in later chapters on feeding.

When the calf reaches an age when considerable roughage can be consumed, the use of suitable kinds, such as alfalfa and clover, corrects the deficiencies of a ration based largely upon cereals and by-product milk substitutes.

Feeding Schedule for Calf Meals. The commercial calf meals and home mixtures recommended as milk substitutes are mostly fed as warm gruels, being mixed with water or milk. As a general rule, one pound of the dry meal, either home-mixed or commercial, is mixed with 9 to 10 pounds of water. The amount of gruel fed is about the same as that which would be used in the case of skim milk.

Table 27 Feeding Schedule for the Use of Calf Meals

AGE	LBS MILK DAILY	LBS GRUEL DAILY	HAY AND GRAIN
1 to 3 days	With dam		
3 to 14 days	10		
14 to 21 days	9	1	Same
21 to 30 days	9	3	quantities
30 to 45 days	6	6	as for skim-
45 to 60 days		12	milk calves
60 to 90 days		14	
90 to 120 days		14	

With the high price now paid for milk, there has been widespread use of special calf meals and concentrated feed mixtures, many of which are now sold as pellets and are fed dry They reduce the time and amount of milk feeding, are easy to use, give satisfactory results when carefully fed, and are coming into general use

A schedule for two different plans of feeding is given in Table 28

Table 28 Daily Milk and Concentrates for Calves Under Two Plans of Feeding

	AGE OF CALF	POUNDS OF MILK	POUNDS OF CONCENTRATES
	1–2 days	With cow	—
	3–7 days	4–9 lb whole milk	—
PLAN I	2d week	5 10 lb whole milk	—
	3d week	6–12 lb whole milk	1/8 lb cereal grain
Using	4th week	8 12 lb whole milk	3/4 lb cereal grain
whole milk		and change to	
then		skim milk	
skim milk	5th 6th weeks	10–12 lb skim milk	1/2 lb cereal grain
	7th 8th weeks	10–12 lb skim milk	3/4 lb concentrate mixture
	3d month	12 14 lb skim milk	1 lb concentrate mixture
	4th 5th months	14–18 lb skim milk	2 3 lb concentrate mixture
PLAN II	1st 2d weeks	Same as PLAN I	—
	3d week	6–10 lb whole milk	1/2 lb calf meal
Using	4th week	6 10 lb whole milk	1 lb calf meal
whole milk	5th week	4 6 lb whole milk	Free access calf meal
with	6th week	2–4 lb whole milk	Free access calf meal
calf meal	7th week	Off milk entirely	Free access calf meal
(or pellets)	To 5th month	No milk	Up to 5 lb calf meal

Plan II of Table 28 applies to those farms where no skim milk nor other liquid by-products are available. Neither is the purchase of powder considered feasible. Here the whole milk is continued to six weeks, and no other milk by-product is used. The calf meal (or pellets) plays the important role. If a commercial meal is used, it should be fed in amounts recommended by the manufacturer.

Weaning. Unless the supply of skim milk is abundant, there is no particular advantage in continuing the milk-feeding period beyond six months of age. When the calf reaches this age, it is capable of eating a sufficient amount of grain and hay to continue its growth unchecked when the milk is eliminated from the ration. The change should be made gradually so as not to upset the animal's digestion or check the growth Feed half the usual quantity of milk for five or six days; then reduce the remainder by half, and if there are no unsatisfactory developments, all milk can be discontinued in four or five more days. When weaning begins, the grain mixture should be changed to one with more bran and oil meal to replace the protein in the milk.

Powdered Skim Milk for Calf Feeding. A very successful substitute for fresh skim milk is powdered or dried skim milk. It is readily soluble in water, can be quickly dissolved in warm water, and fed without delay. While the cost of powdered skim milk is usually higher than fresh skim milk when available, it has a distinct place in calf feeding and is becoming more and more widely used in calf feeding throughout the country. One place where it may be used with advantage is on the farm from which milk is retailed. On such farms a supply of fresh skim milk is generally available a portion of the time but cannot be used to advantage for calf raising on account of a shortage from time to time. Powdered skim milk keeps indefinitely and may be alternated with fresh milk without causing any ill effects to the animal. Another condition suggesting its use is where whole milk is sold at wholesale, leaving no skim milk available, and, if calves are raised, the use of whole milk is necessary. By following the plan outlined in previous paragraphs of using the minimum amount of milk, the whole milk used may be reduced from about 400 pounds to around 160 pounds. The market price of the powder

usually is such that an amount equivalent to 100 pounds of skim milk will cost about one third the wholesale price of the same amount of whole milk At times powder rejected for human food, but equally as good as standard for calf raising, may be bought at a price considerably below the current market price Small quantities of *malted* milk of this class are also on the market and have been found to give good results For calf feeding dissolve one pound of powder in nine pounds of warm water (100° F) and feed the calf the same as if fresh skim milk were used

Whey as a Feed for Calves Where milk is used for cheese-making, it is usual for the whey to belong to the milk producer, and it is used to a small extent as a calf feed As a rule, the whey is fermented to such an extent before it reaches the farm that its use as a calf feed is out of the question Where the cheese is made on the farm, or the whey is pasteurized at the factory, it may be possible to secure it in a sweet, unfermented condition Otis[6] reports a trial in which calves fed on skim milk gained 1 32 pounds a day as compared to daily gains of 1 06 for those receiving whey A Scotch report[7] states that the gradual replacement of whole milk by whey between the third and sixth week, followed by the feeding of whey with grain or other concentrates, resulted in calves practically as thrifty and well grown as check lots receiving skim milk and crushed oats The concentrates fed with the whey included (1) oil meal and fish meal, (2) palm nut meal, and (3) flour middlings and fish meal

Composition of whey The percentage composition of unskimmed whey as compared to skim milk is given as follows

INGREDIENTS	SKIM MILK	WHEY
Water	90 50	93 07
Fat	10	34
Proteins	3 57	93
Sugar	4 95	5 00
Ash	75	60

[6] Otis, Kansas Agricultural Experiment Station Bulletin 126 p 163 (1904)
[7] Bulletin 84 West of Scotland College Farm, in *Scottish Journal of Agricultural* 1 205 210 (1918)

It will be observed that the whey contains a little more fat, but only about one fourth as much proteins as skim milk. The sugar is a trifle higher. The removal of the greater part of the casein in making cheese takes out the most valuable portion of the milk from a food standpoint. If whey is used for calf raising, a grain ration should be selected that replaces as far as possible the constituents removed in the cheese Corn is used with skim milk, since the latter is strong in proteins; but with whey, conditions are different, and the proteins must be supplied. Oil meal is generally preferred for this purpose About one-half pound of oil meal is mixed thoroughly in a gallon of sweet, warm whey, and fed as is skim milk. If it is desirable to raise the calf on whey, it should be given its mother's milk for at least six weeks, and then can be changed to the whey. Some prefer to feed the grain dry. The other details of feeding and care are the same as given in regard to skim milk, and when the whey is secured from a cheese factory, the same precautions against fermentation and introduction of disease should be exercised as in the case of skim milk returned from the creamery. Pasteurization is the only safeguard.

RAISING CALVES WITH THE MINIMUM AMOUNT OF MILK

The basis of this practice is the admission that there is no substitute for milk and that the important thing in calf raising is to give the animal a good start by using milk and then to change the ration as soon as practicable to one of grains and roughage. This method of limiting the milk feeding to a minimum quantity is to get the calves well started on a milk ration, at the same time encouraging them to eat as much grain and hay as possible, and then wean them as soon as they are able to continue to develop satisfactorily on grain and hay alone. This plan was followed experimentally by the Missouri and Minnesota Stations, for the purpose of determining how soon milk feeding could be discontinued without seriously checking the normal growth of the calves. The results are available from eight groups of calves raised successfully according to this plan. The average feed consumption of the calves in the various lots is shown in Table 29.

The results may be judged by the average weights at the age of

Table 29 Data Concerning Calves Raised with the Minimum Amount of Milk

Group	No. Calves	Breed	Average Age at Weaning	Average Feed Consumed to Six Months of Age: Whole Milk	Skim Milk	Grain*	Hay
			Days	Lbs	Lbs	Lbs	Lbs
1	6	Holstein	66	168	700	438	421
2	4	Holstein	60	170	653	505	243
3	3	Holstein	50	453	—	527	265
4	3	Holstein	60	196	379	467	377
5	3	Jersey	63	133	600	430	341
6	2	Jersey	60	406		396	314
7	6	Guernsey	59	375	88	412	295

* Grain mixture Corn meal 4 parts wheat bran 1 part oil meal 1 part

6 months as compared to the normal weight for animals of the breeds represented The data in Table 30 show these facts

All the animals at weaning time were approximately normally developed as compared to skim-milk calves as shown by the percentage of normal in Table 30 For a period of a month to six

Table 30 Average Weights at Six Months Compared with the Normal

Lot	Weight at Six Months	Normal Weight	Per Cent Normal	Average Daily Gain to Six Months
	Lbs	Lbs		Lbs
1	325	349	93	1.37
2	346	349	99	1.42
3	322	349	92	1.28
4	313	349	90	1.18
5	275	260	105	1.24
6	222	260	86	90
7	241	—	—	90

weeks after milk feeding was discontinued, the majority of them lagged behind the normal rate of growth, but this was fully counterbalanced by more rapid development during the remainder of the 6 months' period, and at the age of 180 days they were only slightly below normal in size—with the exception of two animals in the first

and one in the second group which received timothy hay instead of alfalfa during the last 90 days of the trial

In the case of Groups 1, 2, 4, and 5, Table 29, skim milk was fed in about the same amount as is used in regular practice where this feed is available The results indicate that calves can be reared successfully by feeding approximately 170 pounds of whole milk and 650 to 700 pounds of skim milk during the first two months to Holstein calves, and that somewhat smaller quantities will suffice for Jerseys Where whole milk only was fed, about 420 to 450 pounds during the first seven weeks for Holsteins and slightly more than 400 pounds in sixty days for Jerseys proved adequate

Animals in all groups were fed a standard grain mixture, made up of ground corn 4 parts, wheat brain 1 part, and linseed meal 1 part by weight, with slight variations in the amount of the bran at times Grain feeding began as soon as the calves would eat it (which was usually at about two weeks of age), and it was fed to the limit of the calf's appetite up to a maximum of 5 pounds a day The roughage used was alfalfa hay, except in the cases noted above Table 31 gives the feed consumption for the three breeds by 10-day periods

Table 31 Average Amount Hay and Grain Consumed Daily

AGE IN DAYS	EIGHTEEN HOLSTEINS		FIVE JERSEYS		SIX GUERNSEYS	
	Grain	Alfalfa Hay	Grain	Hay	Grain	Hay
	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs
30 40	0 4	0 1				
40 50	0 6	0 3	1 0	0 5	0 4	0 4
50 60	1 5	0 6	1 3	0 6	0 9	0 7
60 70	2 0	1 0	1 6	0 8	1 2	0 7
70 80	2 8	1 3	2 2	1 2	1 8	0 8
80– 90	3 3	1 6	2 9	1 9	2 3	1 1
90 100	3 9	1 8	3 3	2 6	2 8	1 8
100 110	4 4	2 1	3 4	2 7	3 0	2 1
110–120	4 5	2 5	3 4	2 7	3 1	2 0
120 130	4 7	2 9	3 5	2 7	3 2	2 3
130 140	4 7	3 3	3 5	3 2	3 4	2 6
140 150	4 7	3 8	4 1	3 8	3 6	2 5
150 160	4 6	4 2	4 3	4 0	3 7	2 7
160 170	4 6	4 6	4 0	3 7	3 8	3 0
170–180	4 6	5 1	4 6	4 2	4 0	3 1

Individual animals within these groups exhibited some variations from the average, and certain ones received milk for slightly longer periods than others. Those that were fed milk longer entered the grain and hay stage more fully developed. These variations in quantity of hay and grain consumed were all reflected in the growth curves of the animals, which goes to prove that success by this method depends upon the feeder's ability to get the calves started early on grain and hay. Another important factor in this system of feeding is to maintain a balance between the quantities of grain and hay fed. Calves prefer the more palatable grain, and the feeder should endeavor to bring the animals to consume more hay by limiting the quantity of grain. It was observed that certain calves which were consuming a small proportion of hay at the age of five months had fallen considerably behind the normal rate of growth, but prompt recovery followed when the grain was reduced and the animals began to eat more alfalfa.

To summarize briefly, calves can be successfully raised to normal size by weaning at the age of 50 to 60 days, after giving them a good start on milk, and then feeding a good strain mixture and a legume hay—provided they are taught to eat these feeds at an early age, and the hay and grain are fed in approximately equal amounts.

GRAINS

Feeding Grain. The calf should be taught to eat grain as soon as it will take it. This is generally by the time it is three weeks or at most a month old. The grain is best fed dry after feeding the milk. If the calf is with others, it will, when large enough, generally learn from them how to eat. When the calf does not begin to eat grain as early as it should, it can be taught to do so by putting a little grain in its mouth after the milk is drunk. In a few days it will begin to look for the grain, and will eat it, if offered in a box within reach.

For the first few days grain may be kept before the calf. After that the ration given should be such that it will be eaten up clean each time. By the time the calf is six weeks old it usually will eat about one-half pound of grain per day; at the end of two months one pound per day, and a month later two pounds per day. At no time up to six

months is it necessary to feed more than this amount, although, if it is desired to push the calves along rapidly, they may be given more up to the limit of their appetite. Any unconsumed grain should be removed from the feed box or manger and fresh grain fed at the next feeding period.

The most extensive trials with grain supplements were conducted by Curtiss[8] and are given in Table 32.

Table 32. Grain for Calves with Skim Milk. (Four Calves in Each Lot)

	LOT I OIL MEAL	LOT II OATMEAL	LOT III CORN MEAL AND FLAXSEED	LOT IV CORN MEAL
	Lbs	Lbs	Lbs	Lbs.
Milk	3,760	3,752	3,760	3,759
Hay	1,478	1,481	1,478	1,484
Oil meal	429			
Oatmeal		605		
Corn meal			538	601
Flaxseed			59	
Gain in 74 days	483	498	489	509
Average daily gain per head	1.63	1.68	1.65	1.72
Dry matter per lb of gain	4.13	4.31	4.32	4.16
Cost of feed per lb of gain, cents	2.40	2.40	2.0	1.80

These data show that satisfactory results were obtained from all four lots, but on account of the lower market value of corn, Lot III made the cheapest gains.

Variety of Grains May Be Used. The general conclusion from the experimental work, which is borne out by long experience of practical feeders, is that there is little difference in results from different grains. Some feeders have assumed that linseed oil meal should be an especially satisfactory supplement on account of its high food value for other purposes and its palatability. However, so long as the calf is receiving skim milk, it has an abundance of protein of the best possible quality, and there is no reason for adding a high protein concentrate such as linseed oil meal. What is needed by the calf primarily is a concentrate that will supply additional energy. This is

[8] Iowa Agricultural Experiment Station Bulletin 35, p 759 (1897)

secured about as readily from one concentrate as from another The one to use should depend upon what is available and upon the market price

In the corn belt where an abundance of corn is always available and where corn is usually cheaper than other grains, it will be the most satisfactory to use, and it will be unnecessary to buy feeds not grown on the farm A mixture of corn and oats is widely used Kafir

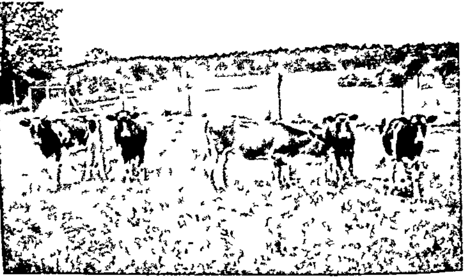

FIG 49 A group of skim milk calves on pasture Up to two months calves do best kept in the barn Later they may be given the freedom of a special pasture

corn and other grains of the same family also give good results if fed ground

Whole Grains Preferred. It was found by Otis[9] that shelled corn gives equal, if not better, results than corn meal, after the calves were well started eating grain Experiments with self feeders have demonstrated that calves prefer whole corn and oats to the ground grain and while the cost of grinding is not very great it is good practice to cater to this preference, as it will result in slower eating and thorough mastication As the calves approach weaning time, if corn is the ration fed a change can with advantage be made to part oats,

[9] Kansas Agricultural Experiment Station Bulletin 126 p 163 (1904)

bran, or an oil meal. Otherwise the ration may become too wide and not contain a sufficient amount of protein for best growth.

Feeding Hay and Pasturing. Calves will begin to eat hay if it is placed before them about as soon as they will eat grain. Hanging a small bundle of hay by a strap in the middle of the pen is an excellent way of getting calves started to eat hay. For young calves some feeders prefer early-cut timothy to clover or alfalfa, as the calf may eat more of these very palatable roughages than it can properly digest. Further, clover and alfalfa are rather too laxative and tend to produce scours. Hay is generally fed in a rack where the animals have free access to it, except when a good quality of alfalfa hay is fed, when it may be necessary to limit the amount during the first two months. For the calf under three months of age, good hay is preferable to pasture grass as roughage on account of the laxative nature of the grass. From the age of about three months, access to grass supplies the roughage in an entirely satisfactory manner.

OTHER ASPECTS OF CALF CARE

Importance of Keeping Pails Clean. The greatest cause of sickness in hand-raised calves is feeding from dirty pails or cans. Every utensil which comes in contact with milk to be used for feeding should be kept clean by scalding as thoroughly as though the food were to be used for the owner's family. A good rule is to keep the calf pails as clean as the milk pails. In feeding grain, no more should be fed than will be eaten up clean. If grain is allowed to remain in a trough, it often becomes damp and partly decayed, and may cause sickness, just as dirty pails will often do.

Clean Pens and Barns a Necessity. Another point to be kept in mind is that the young calf must be kept in a clean, well-bedded stall while in the barn. Experience has taught many men that a calf will not do well in a damp, dirty pen or stall, under which conditions pneumonia is common. The calf needs all the sunlight it can get, and the well-lighted stall is always best. In arranging a barn, the sunniest and warmest part should be reserved for the calf pens. In the summer the calf should have access to a small pasture with plenty of shade.

Plenty of Water Needed. An abundance of clean water should

be accessible at all times or at frequent intervals, as the calf is not satisfied with milk alone as a drink, and often during the day wants to drink a little water at a time This thirst for water is often overlooked when calves are raised by hand, and as a result the calf is thirsty as well as hungry, and gorges itself with milk when it has a chance

Mineral Matter Our present knowledge of mineral requirements for growing animals shows that calves should always have an abundant supply of at least calcium and phosphorous Keeping a supply of finely ground bone meal before the calves will insure a sufficient supply of calcium and phosphorus Salt should also be kept within reach when the calf is old enough to eat grain and hay A more extensive discussion of the importance of minerals is given in the chapters on Nutrition and Feeding

Fall or Spring Calves. There are a number of advantages in arranging that the calves to be raised by hand shall be dropped in the fall The calf can be kept growing nicely on skim milk until the grass comes, then weaned and turned out to pasture without checking its growth in the least The disadvantages of winter feeding and cold weather are more than offset by the hot weather and annoyances from flies experienced by the spring calf For the calf under six months it does not make much difference whether the roughage be grass or hay In the winter season the young calf is also more apt to receive the careful attention it needs than during the busy summer season

Summer calves when young are greatly annoyed by flies and can be made most comfortable by allowing access to a darkened stall during the daytime Breeders of valuable purebred animals find it a good practice to inclose a small pen with fly screen for the young calves

CHAPTER XVII

Calf Raising and Calfhood Diseases

Importance of Early Care and Feeding. The systematic planning of a practical feeding program for all calves is very important. It should fit the individual conditions of each dairyman. This will take into account his method of selling milk, whether as market milk, to the condensery or cheese factory, or as home-separated cream for the creamery. It will also take into account the number of calves to be raised, whether as replacement heifers for the herd or as veals for the market.

In every case, however, the aim should be a healthy, thrifty, vigorous calf and one that at the end of the minimum milk or milk-substitute period will either go to the market as a veal at a profit, or continue to grow into a satisfactory replacement for herd development.

Starting Calves on Grain and Roughages. While milk, whole or skim, has no substitute as a feed for young calves, its importance is in the first few weeks of the life of the calf and decreases steadily in importance as the calf grows older. Young calves will begin to nibble at good hay at two weeks of age. It is desirable to have them do so as it starts early stomach and rumen development. Successful and economical calf management depends upon getting the calf over onto a supplementing or complete grain- and roughage-feeding schedule as early as satisfactory development will permit.

GRAINS AND ROUGHAGES

Grain Mixtures Several recommendations of supplementary grain rations have already been made Whole or cracked corn is most palatable and best adapted for young calves Coarse chopped oats may be added later, likewise wheat bran and oil meal At weaning time it is well to increase the proportion of oil meal and bran in order to replace the protein of the milk Almost any mixture of home-grown grains makes a satisfactory supplementary feed for calves when the foregoing suggestions are borne in mind

Roughage Experiments have proved the legume hays are preferable to timothy or prairie hays for growing calves because they contain more bone making minerals and muscle-building proteins It is essential that all hays be well cured, bright leafy, and of good quality Alfalfa or clover hay should be fed from the start, but if scouring is prevalent it is well to feed timothy, or mixed clover and timothy, until that tendency is overcome Alfalfa of very good quality should be fed moderately until the calves become accustomed to it, as its laxative qualities may result in looseness where large amounts are eaten This precaution is seldom necessary if the hay is of a non-legume kind

Silage can be fed to calves but nothing can be gained by feeding silage to calves that are less than two months of age, for the amount eaten is small, and in case of digestive disturbances which frequently occur at this young age it may prove detrimental Silage varies materially in its acid content from year to year, and high acidity causes scouring For this reason it is well to feed it only in limited amounts and use fresh silage of the best quality Any material left in mangers should be cleaned out before the next feeding

CALF FEEDERS AND TIES

Calf Feeders Several calf feeders for the milk-feeding period have been devised and are used in a small way They are mostly some type of a nipple pail having a rubber nipple for the calf to suck, and a tube of some kind to draw the milk from the pail The claim is made that it is better for the calf to drink the milk slowly and by so

doing the milk goes directly to the true stomach rather than to the paunch, thus aiding in better digestion.

In practice it is found difficult to keep the tubes clean, and it is more work to feed the calf in this way than by teaching it to drink from the bucket. As to the injurious effects of rapid eating, it is doubtful if saliva has much to do with the digestion of the milk, since the principal office of saliva in digestion is to moisten the food and convert the starches into soluble sugars, and there is no starch in milk. Rapid gulping of milk, however, is thought to cause injurious curdling within the stomach and sometimes other digestive disturbances.

Separate Pens for Calves. Where valuable calves are raised and it is desirable to take every precaution to keep them in good condition, it is advisable to arrange a series of small pens so each animal may be kept by itself. This not only allows each animal to get the proper amount of feed, but enables the feeder to observe the individual more readily and detect any unusual conditions. Much of the sickness of calves, including a portion of that usually classed under the term "scours," is really infectious in character. For this reason, in the best-equipped barns the younger calves are kept in individual pens, with the partitions of solid construction to prevent any communication from one animal to another. A case of common scours from indigestion may often be stopped by decreasing the feed of a certain calf after observing an abnormal condition of the manure so slight that it would not be possible to locate the affected animal in a group.

Raised Removable Floors. The use of raised and removable floors in calf pens has become very widespread in recent years. Such floors are made of heavy expanded metal strips, such as are used in concrete floors and airfield runways. These strips allow an air space of four to six inches above the floor and allow all urine or water to drain through the bedding. They also keep the bedding drier and warmer. Such false floors can be purchased ready-made or can be made by hand to fit the pen size. They can also be made of narrow wood strips, but are less durable or satisfactory.

Stanchions for Calf Feeding. The best arrangement next to the

individual pen, and the one most commonly used, is a large pen or series of pens constructed in modern barns, of steel—*although wood* will serve the same purpose—with a row of stanchions along the front for tying the calves during feeding Some means of fastening the calf during feeding should be provided, not only to save labor, but to allow each calf to get its proper share of milk and grain Calves should never be fed in a trough, as some will drink faster than others and be overfed, while others will be underfed The same rule applies to the feeding of grain

Stanchions for calves are constructed much like *the old-fashioned* rigid stanchions for cows, but smaller A feed trough is put in front and divisions are provided to keep the feed of each calf separate The pail of milk is set in the trough for the calf to drink After drinking the milk, the proper amount of grain is put in the trough, and the calves are left tied for some time to eat their portion This usually prevents them from forming the habit of sucking each other, which is a point of great importance If the calves are in the pasture, a convenient way is to fasten the stanchions on the fence

Calf stanchions are usually made from thirty-six to forty-four inches high and twenty-eight inches from center to center, with a *space of about four and one-half inches for the neck The feed trough* should not be too wide, about fourteen inches is ample, with a depth of four inches where the stanchions are in the pasture and the calves are not fed hay A sloping board about twelve inches high along the front of the manger will prevent the calves from spilling the grain out of the manger In the barn provision should be made for holding a sufficient supply of hay A rack constructed of steel or wood and placed with the back against the wall and at suitable height is satisfactory for this purpose

VEAL PRODUCTION

Under European conditions, where few cattle are kept especially for meat production, veal occupies a decidedly important place in the meat supply of the people In America, where the abundance and comparative cheapness of feed has made possible the raising of large numbers of animals primarily or exclusively for beef, veal is of far

less importance and has not received much attention. In fact, veal calves are merely a by-product of milk production, and the source of supply for a city is in general the same herds which supply it with milk. In milk-shipping districts the practice is altogether too common of selling the heifer calves as well as the males for veal.

Returns in Veal Production. The first question that arises in connection with the veal calf is whether the price received justifies the amount of milk necessary to feed the animal until it can be put on the market. The veal calf commanding the highest price on the market is one weighing from 140 to 160 pounds at an age of from six to eight weeks. The carcasses of such calves are characterized by

Table 33. Relation of Birth Weight of Calf to Veal Production

BIRTH WEIGHT OF CALF, LBS	AMOUNT OF MILK FED, LBS.	VALUE OF MILK AT $3 00 PER 100 LBS	VALUE OF VEAL AT 25¢ PER LB
40	1,100	$33 00	$37 50
50	1,000	30 00	35 00
60	900	27 00	35 00
70	800	24 00	35 00
80	700	21 00	35 00
90	600	18 00	35 00
100	500	15 00	35 00

flesh of light color and fine grain. The most important factors contributing to the value of a veal are condition and weight for age. With these facts in mind it can readily be seen that the birth weight of the calf is a pertinent factor in the economy of its use for veal, since a calf weighing 100 pounds at birth will reach the most desirable weight in half the time and on approximately half as much milk as the 50-pound calf. Assuming that an average of 10 pounds of milk is necessary to produce one pound of gain, and that milk is worth $3 per 100 pounds and veal 25 cents a pound, the cost of raising veal calves to weight of 150 pounds is as shown in Table 33.

At these values a calf weighing much less than 75 pounds at birth will not bring enough as veal to pay for the milk it consumes. Whether the calf can be raised profitably for veal clearly depends upon the price of milk, the market price for veal, and the size of the calf at

birth It is often found that it costs more to feed calves, especially of the smaller breeds, than is received when the calf is sold, and for this reason many do not attempt to do so, but destroy at birth all calves not needed for breeders. Where a number of cows freshen at intervals, some of the calves are often raised that otherwise would not be, by feeding them the milk of the fresh cows up to the time they are fit for market

Approximately 10 pounds of milk are required for every pound of gain made by the veal calf, but seldom will the selling price of the calf

Table 34. The Relation of the Price of Milk to Cost of Veal Production

MILK PER CWT	PRICE OF VEAL PER POUND LIVE WEIGHT								
	8¢	9¢	10¢	11¢	12¢	14¢	16¢	18¢	20¢
1 40	$1 93	$3 27	$5 08	$7 35	$9 13	$12 74	$16 34	$19 94	
1 60	14	1 94	3 30	5 56	7 35	10 95	14 56	18 16	
1 80	−1 54	16	1 51	3 76	5 56	9 17	12 77	16 38	
2 00	−3 43	−1 63	− 28	1 98	3 33	7 38	10 99	14 59	
2 20	−5 21	−3 41	−2 06	19	2 09	5 60	9 20	12 81	$16 41
2 40	−6 99	−5 20	−3 84	−1 59	21	3 81	7 42	11 02	14 63
2 60	−8 78	−6 99	−5 63	−3 37	−1 51	2 03	5 64	9 15	12 84
2 80					−3 36	25	3 85	7 45	11 06
3 00						−1 53	2 08	5 68	9 28
3 40							−1 49	2 11	5 72

by the pound equal the market value of 10 pounds of milk. Under common conditions every pound of gain on a veal calf is made at a loss. The only profit made is by selling the weight of the calf at birth, and it follows that as a rule, the younger a calf can be sold, the greater the profit, even though the total income is less. It is for this reason that the tendency is to sell the calf as young as possible and that cities and states have found it necessary to establish regulations concerning the minimum age at which calves may be sold for veal. Three weeks is the standard regulation, but it does not prevent many from reaching the market before this age is reached. The practice of putting calves on the market too young results in much poor quality and a relatively small demand.

Costs of Veal Production. Bechdel[1] has prepared a table from

[1] Pennsylvania State College Annual Report, 1916–17, pp 337–347

his experimental results showing the returns above feed with milk and veal at varying prices. The animals furnishing the data upon which this table is based were fed an average of 53 days on whole milk and were mostly from the breeds which insure large birth weights. The average daily gain was 1.85 pounds and milk was used at the rate of 9.4 pounds to each pound of gain.

Classification of Veal on the Market. Calf carcasses weighing less than 300 pounds and having comparatively light-colored flesh are classed as veal. The grade and value of a calf carcass depends upon its form, quality, finish, and weight. The most desirable is a well-fatted calf about six weeks of age and weighing 120 to 140 pounds. The flesh should be as nearly white as possible. Dark-colored flesh is an indication of too much age, or too much coarse feed. Calves four to six weeks old are preferred, while some are at their prime at eight weeks. Calves under three weeks are condemned. The following are the usual market grades:

GRADES	EXTREME WEIGHTS	AGE
Choice	80 to 120 lbs	4 to 8 weeks
Good	70 to 130 lbs.	6 to 10 weeks
Medium or fair	60 to 160 lbs.	5 to 12 weeks
Light or common	40 to 75 lbs.	3 to 8 weeks
Heavy	150 to 300 lbs.	Wide range

The market price varies widely for veal calves, depending upon the quality. The most common faults are: either too heavy or too light, lacking in fat, or flesh color too dark.

Feeding for Veal. It is a well-established fact that a first-class veal calf must be fed exclusively upon whole milk, or at most must be allowed to consume a very limited amount of hay and grain. The calf is generally taught to drink from a pail, as it is not desirable to have a cow that is to be milked nursed by a calf more than 2 or 3 days at most. From 10 to 12 pounds of milk a day are used at first and gradually increased until a vigorous calf may receive 8 to 10 pounds at a feeding twice a day before it is marketed.

Bechdel, using 11 calves, mostly grade Holstein, secured an average daily gain of 1.85 pounds for 53 days with an average consumption

of 9 4 pounds whole milk for each pound of gain The author, using 8 Holstein calves, secured an average daily gain of 1 46 pounds to 30 days of age using 10 02 pounds of milk for each pound of gain A group of 10 Jersey calves weighing 49 pounds at birth averaged 1 3 pounds daily gain for the 30 days and used 9 4 pounds of milk to the pound of gain Hayward reports average daily gains ranging from 1 3 to 2 2 pounds with a consumption of 9 8 pounds of milk for each pound of gain It will be observed that in all cases a pound of gain required about 10 pounds of milk

Unless the calves are fed a sufficient quantity of milk to reach the market in good condition, there is no reason for feeding them for veal at all, since the thin and inferior calves bring little more than the value of their hides on the market and seldom pay for the milk they have consumed Experiments have been made to determine the possibility of using skim milk or milk substitutes for feeding calves designed for sale as veal The results have shown that this practice cannot be followed successfully While it is entirely practicable to raise calves for other purposes by these means, to do so satisfactorily requires the use of whole milk for a period about as long as the period of feeding a veal calf A calf put on a milk substitute at an early age will be in a thin or more or less unthrifty condition at the age to be marketed for veal and will be almost unsalable for this purpose, although it may later develop into an entirely satisfactory dairy animal

If an abundance of skim milk is on hand, it may pay to feed calves for meat production to an older age before putting on the market and in this manner utilize the skim milk Some dairymen using the dairy breeds find this fairly satisfactory, selling the calves at an age of from eight to ten months However, the dairymen as a rule will find it more profitable to utilize the skim milk by feeding it to growing pigs or laying hens than to raise this quality of meat.

DISEASES OF CALVES

The whole field of diseases of calves and calf ailments and their prevention and cure is an important one and one in which there is still too little accurate information It affords a splendid opportunity

for study and research. The subject deserves more serious consideration by a number of investigators, as the nature of some of the maladies which afflict young animals, and methods of control and cure, are still far from being well understood. This lack of knowledge is causing great economic waste, as the rate of mortality for young calves of the dairy breeds is appallingly high. Many of the animals are lost each year through lack of care and intelligent handling on the part of feeders.

Disease-Free Foundation. The first step toward insuring healthy calves in any herd of cattle is to mate only animals that are free from disease of the reproductive organs. When conception occurs as the result of the mating of two animals with normal and healthy genital organs, and care is taken to protect the pregnant cow from subsequent exposure to malignant diseases which would affect her reproductive ability, then we may be reasonably sure that the offspring will be born in perfect health.

Importance of Sanitary Quarters. The next step is to take proper precaution for the reception of the new-born animal, by providing the dam with a clean, roomy stall, freshly bedded with dry clean bedding. After the calf is born, remove any persistent membrane or mucus from the mouth and nostrils, and allow the cow to lick it dry. Later the navel cord should be dipped in tincture of iodine and dusted with boric acid.

All precautions having been observed to insure a healthy calf at birth, the animal, if worth raising to maturity, can best be raised by housing it in sanitary, dry, well-ventilated quarters with provision for sunshine, fresh air, and exercise, and by feeding it to induce satisfactory growth and development.

Scours from Indigestion. The most common ailment of calves, particularly those which are bucket-fed, is scours, or looseness of the bowels This trouble should not be confused with white scours, or calf cholera, which will be discussed later on. Common scours, or indigestion, is due to various causes, the chief of which are overfeeding; use of old milk, sour milk, cold milk, or milk too rich in fat; irregular feeding; dirty pails or mangers: unsanitary, damp pens; or occasionally, even, too much leafy alfalfa.

The first symptoms are listlessness, loss of appetite sometimes accompanied by slight bloating, and a diarrheal condition causing the discharge of semifluid, dark-colored, foul-smelling feces, which stain the tail and hocks of the animal On the first indication of the disorder, the ration should be cut down to one half the usual amount. It is well to add one teaspoonful, per pint of milk fed, of a mixture of one-half ounce of formalin in 15½ ounces of water After two or three feeding periods, the milk given may again be increased to the usual quantity The formalin should be given for two or three days at least

When a severe case of scours appears, the feed should be at once reduced A drench of three ounces of castor oil in a pint of milk may be given then to advantage This may be followed by a teaspoonful of a mixture of one part salol and two parts subnitrate of bismuth three times daily for two or three days until the condition of the animal improves It is well to give the animal the formalin mixture for several days while it is recovering from a severe attack If the discharge from the bowel has a sour odor, up to one pint of lime water should be added to the milk

Neglected cases of scours in time become chronic, causing a highly inflamed condition of the digestive tract The animal grows listless and loses flesh, and the hide is tight and the hair upstanding These chronic cases will yield to careful treatment but it requires a long period for full recovery from the severe setback in growth

While ordinary scours is not necessarily contagious, it is good practice to separate sick calves from the rest of the herd so that they may be watched and given proper treatment This also prevents the other calves from becoming soiled by the droppings of the scouring calves

Bloody Scours Another form of scours which attacks small calves or those of low vitality at the age of three to five weeks is sometimes called bloody scours, because the discharges from the bowels are streaked with blood and sometimes appear to be pure blood This disease works rapidly, and calves often succumb in two or three days It is apparently highly contagious and the weaker animals are very susceptible It is therefore essential that calves

should be isolated as soon as detected, and all soiled bedding destroyed and stalls disinfected before healthy animals are allowed to occupy them. Some success has followed the use of fluid extract of gelsemium administered in doses of two teaspoonfuls three or four times a day. Recovery is slow and extreme care should be exercised when feeding is resumed.

White Scours. White scours is a germ disease which attacks calves at birth or shortly after they are dropped. Symptoms are: dullness, frequently inability to arise, sunken eyes, increased respiration, and profuse discharge of dirty or yellowish white pasty feces with a highly offensive odor. The disease is ordinarily fatal, and the body should be burnt or buried to prevent spread of the malady, which is highly contagious Similar precautions should be observed in disposing of bedding and other materials fouled by the discharges.

It was at one time believed that this disease gained entrance through the broken navel cord, but later investigation indicates that there are three sources of infection. (1) During intra-uterine life the fetus may swallow the germs in the amniotic fluid; (2) after birth the young calf is exposed to infection in the discharge from the vulva of the cow which foul the udder and teats; (3) the presence of other sick calves in adjacent pens with open partitions, or soiled bedding in the calf pen, may expose the newborn calf to the disease.

The fact that white scours is often prevalent in herds affected severely with contagious abortion has led some authorities to conclude that there is a close association between the two diseases as well as calf pneumonia and arthritis, or acute swelling of the joints in calves. However the case may be, it is well to take particular pains to isolate all calves dropped by cows showing abnormal discharges from the vagina or retained afterbirth. This will prevent their infecting other calves if the disease develops. The navel cords of all calves should be treated with tincture of iodine at birth and dusted with boric acid.

Treatment for white scours. If an outbreak of white scours should occur, the first step to check it would be to destroy the carcasses of any dead calves, together with all bedding and soiled material from

the calf barn The calf pens and maternity stalls should be thoroughly disinfected A serum is also on the market which has given results in preventing this disease In using the serum, each calf is given a dose hypodermically soon after birth, followed by a dose daily if scouring develops, until the feces are normal Along with this treatment the calf may be given an enema of physiological salt solution (80 grams of salt to a quart of water) and a fourth of one per cent of Lugol's solution to remove the meconium, the material found in the bowel at birth This treatment should be given before the calf is permitted to feed The udder and teats of the cow should be thoroughly cleansed and disinfected before allowing the calf to suck or before drawing milk to feed it The calf should receive the dam's milk only for eight or ten days

The serum is expensive and its use is only justifiable where the calves are valuable Two kinds are available, white scours serum which is best for prevention and first treatments, and polyvalent colon bacterin, which is used for chronic cases Insoluble sulpha compounds are being used to some extent and show much promise Both serum and the newer drug compounds should be administered only by a competent veterinarian

Calf Pneumonia One form of bronchial pneumonia which attacks the lower part of one or both anterior lobes of the lungs is usually associated with white scours and bacteriologically is closely related to the other disease This disease acts slowly and usually affects the older calves It is accompanied by loss of appetite, general weakness, and more or less coughing The calf serum mentioned above is recommended for treatment, as the infection is believed to be due to the same organism which causes white scours

Another form of pneumonia is often contracted by calves which are housed in cold, poorly ventilated quarters or subjected to severe exposure in inclement weather This disease is accompanied by high temperature ranging from 104° to 106° F, complete loss of appetite, harsh, dry skin, upstanding hair, and short respiration accompanied by a spasmodic jerking in the flanks Severe cases are ordinarily fatal, and the only treatment recommended is placing the

animals in dry, warm quarters, blanketing them, and administering a mild purgative such as castor oil. If the animal is successful in combating the disease, it is usually left in an extremely weak condition, and the use of nux vomica as a stimulant may be resorted to until its strength returns with renewal of appetite.

Arthritis. This is another condition associated with white scours. The symptoms are stiffness of one or more of the joints of the legs, accompanied by swelling and a feeling of hotness and soreness to the touch. The animal shows no inclination to move about. Since our present knowledge indicates a close relationship between this condition and white scours, the same precautions and methods of control are recommended for its treatment.

Navel Ills. Painful inflammation of the region of the navel, accompanied by discharge of pus, is sometimes found in calves two or three days after birth, and this trouble is ordinarily traceable to infection acquired at the time of birth or from dirty bedding. Prevention is almost certain if the navel is treated as recommended and due care exercised with regard to cleanliness of the calving quarters. If there is a discharge of pus or swelling, this should be opened and cleaned with disinfectant solution, and packed with cotton saturated with iodine or thoroughly powdered with boric acid. Recent research indicates that the administration of vitamin C by subcutaneous injection is highly successful in the control of this disorder.

Ringworm. This is a form of skin infection which often breaks out while the calves are in winter quarters, and is characterized by unsightly spots from which the hair is lost. This is accompanied by itching which irritates the animals. It is caused by a fungus. The disease is characterized by round, sharply defined, scabby lesions containing broken hairs. The lesions vary in size from one-half to one and one-half inches in diameter. They are most often found about the eyes and ears of the calf and may spread to other parts of the body. The disease spreads rapidly and can only be checked by cleaning up the quarters, and by applying whitewash or disinfectant to the walls and partitions. The skin over the infected areas should be washed with soap and water, scraped, and then treated with tincture of

iodine Excellent results have been reported in the use of phemerol solution[2] The application of 1 to 1000 phemerol solution two times per week for three or four weeks is usually successful even in severe cases

Lice Calves are subject to much annoyance by these parasites, especially when closely housed for the winter Their presence can be detected by a disposition on the part of the calves to rub themselves, and when the hair is parted over the withers and along the spinal column, the lice can be seen It is well to examine the calves during the winter and spring for the presence of lice To rid the animals of the parasites, they may be washed with two per cent cresol solution and the treatment repeated after a week or ten days to kill the lice which hatch from the eggs If the weather is too severe to permit washing, relief can be obtained by dusting the infested parts with Derris or Rotenone (¾ per cent) powder using care not to get the material into the eyes This treatment can be repeated as often as necessary Cattle lice are also controlled with DDT, six and one-half ounces of 50 per cent wettable compound to 10 gallons of water is the usual mixture For best results give a second treatment 18 to 21 days after the first. Treatment for lice should start in the fall if possible, if DDT is used Otherwise use the dust treatments

[2] Bryan and Young, M.S.C Veterinarian, Vol B No 3 (1945)

CHAPTER XVIII

The Growing Dairy Heifer*

From the time a heifer reaches the age of six months and until she freshens is a period very often neglected in her care and management. This is true because the heifer has passed the danger period in which she is subjected to many calfhood diseases and has not yet reached the time when she is bringing in an income, and so it has been a period when the average dairy farmer usually just "roughs her through." While it is true that one should keep such heifers just as cheaply as is consistent with good management, nevertheless there are many things which must be known and done in order to develop them and bring them into milk production.

This is the period in which growth is pretty well completed: the period when the heifer is bred and in which her udder is developed, and so one must know about growth, what it is, and how it can be measured and maintained; about pregnancy and gestation and the factors concerned with development of the udder and the bringing of the animals into profitable production.

The economic importance of a thorough study of the problems of growth and factors bearing thereon has made this a fruitful field for research and experimentation, and the progress of scientific study has led investigators deeper and deeper into the mysteries of growth, the natural laws and forces which govern it, and the influences and effects of nutrition on the functioning of those laws and forces.

Nature of Growth. Growth is a term used to embrace that series

* Author: Dr H O Henderson, Head, Department of Dairy Husbandry, West Virginia University.

of changes in size and structure by which an individual of any species develops from the fertilized egg to maturity Increase in size is brought about by three processes, namely, an increase in the number of cells, an increase in the size of the cells, and the deposition of material between the cells The first of these is without doubt the most important In all higher organisms, increase in size is accompanied by a differentiation of the cells into groups, called tissue and organs, many of which assume a high degree of specialization of function

Two Factors Concerned in Growth Growth is an exceedingly complicated phenomenon The factors operating in growth are of two general classes (1) the internal, and (2) the external

The internal factors are those that are set free at the fertilization of the ovum and continue at a continually slower rate until the full size has been reached, unless some adverse conditions are encountered The cause of this growth stimulus is thought to be certain hormones, the secretions of the endocrine glands The endocrine glands that produce hormones related to growth are the pituitary, the pineal, the thymus, the thyroid, the parathyroids, the adrenals, the pancreas, and the ovaries or testes The secretion of these hormones is not under the control of the feeder of the growing heifer to any great extent, and they continue to act even under adverse conditions They seem to influence the growth of the skeleton to a greater extent than that of the fleshy part of the body

The external factors are those that are largelv under control of the herdsman, and consist of the nutrition, housing care, and management of the animals It is these factors that the good herdsman should strive to provide well for the growing heifers

Limits of Growth The upper limit of the skeletal size attained by any individual under favorable conditions is determined by heredity, and even the greatest intake of feed will not cause this limit to be exceeded, although it may influence the optimum being reached This heritage falls within the limits of the size of the species, and there are found in every species individual variations between the upper and lower limits, although the great majority of the members will be grouped close to the average size Animals that have experienced adverse conditions as to feed and care may never reach

their maximum size, especially if such adverse conditions have been too severe or have lasted for too long a time. However, after a period of retarded growth, an animal when again given good feed and care will grow at a faster rate than normal and will continue to grow for a longer period of time. This may make up for the loss due to the adverse conditions unless such conditions have continued for too long a period.

Measuring Growth. Formerly, the growth of larger animals was measured almost entirely by their body weight. Since it is now known that the body weight and skeletal growth are, to a considerable degree, independent of each other, the weight itself is not the most satisfactory way to measure growth. This is because the weight, which is largely increases in the soft tissues, is increasing for the most part in geometrical progression, while the skeletal growth, which occurs chiefly at the ends of the bones, is mostly linear and proceeds in arithmetical progression. Furthermore, the growth of the skeleton continues to a certain extent, whether the fleshy tissue is storing up energy during a period of liberal feeding, or losing energy as a result of a low plane of nutrition. It has been found experimentally that the influence of the factor of nutrition alone may cause a variation of over 40 per cent in the weight of animals; whereas the variation in height may be less than 10 per cent for the same group of heifers. The weight of an animal certainly cannot be used alone as a fair measure of growth when, in relation to the growth of the skeleton, it can so easily be made to fluctuate between such wide limits. No one single term has been devised to measure growth. It has been found that the growth of various parts of the body proceeds in rather definite ratios. The rapid increase in length comes at the same time as the rapid gain in height or circumference; so the measurement taken of the growth of one part of the body makes it possible to estimate the rapidity of growth and the time at which it occurs. However, in practice, because of the small limit of error, and the ease with which it can be taken, the height at withers has been generally selected as a satisfactory measure of skeletal growth. The growth of the animals, therefore, may be measured by combining (1) gain in live weight, and (2) increase in height at withers.

Normal Growth. To afford a basis for the measurement of growth, weights and measurements have been taken at the University of Missouri and at other institutions, of purebred animals of the various breeds handled under what were considered normal conditions These data, given in Tables 35 and 36, may be used as standards in studying animals of the breed represented, and so are known as normal growth tables Dairy farmers can compare the size of their calves and heifers with the data from these tables to determine if they are growing normally

Estimating Weight of Dairy Animals Many farms do not have any convenient way of weighing animals There is a fairly close correlation between the heart girth measurement of an animal and its body weight Table 37 has been prepared by the Bureau of Dairy Industry, U S D A , giving an estimation of the weight of dairy cattle derived from their heart girth measurements While the figures of this table are not exact, they are a convenient way to estimate the weight of an animal Animals in high condition will weigh more than the table indicates and thin ones less Long, slender animals will overweigh the examples in the table and short chunky animals will underweigh This system is much used in Europe where farm scales are not in common use

Factors Influencing Growth There are several factors which have an influence upon growth and the final size of an animal including size at birth, breed, management, feeding, gestation, and lactation, and these will be discussed separately

Size at birth Within a breed, the calves from immature dams or those of advanced age are usually smaller than are the offspring of cows five to ten years old The nutrition of an animal during gestation does not affect the size of the calf at birth to any appreciable extent except under the most extreme conditions It is evident, then, that within a given breed there are no potent factors at work to influence the development of a calf *in utero* which might reflect on its future growth Therefore, we may assume that regardless of birth weight normal and healthy animals are born with an equal chance to grow However, there is considerable variation in birth weights A careful study of the growth of calves grouped according to birth weights

Table 35. Normal Weight of Females

AGE IN MONTHS	AYRSHIRES	GUERNSEYS	HOLSTEINS	JERSEYS
	Lbs	Lbs.	Lbs.	Lbs
Birth	70	65	90	53
1	84	77	112	67
2	111	102	148	90
3	146	133	193	121
4	184	173	243	158
5	227	216	297	199
6	272	260	355	243
7	318	305	410	286
8	361	350	462	324
9	401	389	509	360
10	440	427	552	393
11	475	459	593	420
12	506	490	632	450
13	531	524	671	479
14	556	556	705	507
15	584	584	746	530
16	616	605	782	558
17	642	634	809	580
18	674	663	845	601
19	697	686	878	622
20	721	712	912	642
21	745	737	952	665
22	768	763	986	684
23	793	788	1024	708
24	819	818	1069	733
27	901	876	1151	816
30	970	880	1120	824
33	1016	905	1130	832
36	1023	901	1165	855
39	1047	924	1176	899
42	1081	952	1202	895
45	1130	971	1197	898
48	1173	990	1232	897
51	1110	980	1261	927
54	1133	1024	1271	952
57	1154	1031	1305	944
60	1157	1055	1330	937
63	1180	1043	1310	948
66	1189	1051	1312	955
69	1197	1073	1343	966
72	1182	1093	1317	973
75	1203	1042	1320	964
78	1251	1094	1357	998
81	1248	1071	1400	991
84	1164	1066	1401	959
87	1184	1065	1402	952
90	1225	1053	1358	1002
93	1245	1067	1335	984
96	1176	1070	1365	909

Table 36. Normal Height at Withers of Females

AGE IN MONTHS	AYRSHIRES	GUERNSEYS	HOLSTEINS	JERSEYS
	Inches	Inches	Inches	Inches
Birth	—	26 6	29 1	25 7
1	27 2	28 2	30 6	27 0
2	28 8	29 8	32 3	28 9
3	30 8	31 6	34 3	30 6
4	32 6	33 5	36 2	32 6
5	34 6	35 3	37 7	34 5
6	36 0	36 9	39 7	36 2
7	37 2	38 4	41 1	37 7
8	38 5	39 9	42 3	39 0
9	39 6	40 9	43 5	40 1
10	40 6	41 7	44 4	40 9
11	41 4	42 6	45 3	41 7
12	42 2	43 3	46 0	42 2
13	42 8	43 9	46 7	42 8
14	43 3	44 6	47 3	43 3
15	43 8	45 0	47 9	43 9
16	44 4	45 3	48 5	44 4
17	44 9	45 9	48 9	44 7
18	45 3	46 4	49 3	45 2
19	45 8	46 7	49 8	45 5
20	46 1	47 0	50 2	45 9
21	46 5	47 3	50 6	46 2
22	47 1	47 7	51 0	46 2
23	47 2	47 9	51 3	46 7
24	47 5	48 0	51 7	46 9
27	48 3	48 9	52 2	47 7
30	48 7	49 3	52 5	47 9
33	49 2	49 7	52 7	48 0
36	49 6	49 9	53 0	48 2
39	49 9	50 0	53 1	48 6
42	50 0	49 9	53 2	48 6
45	50 3	50 1	53 2	48 5
48	50 5	50 4	53 3	48 5
51	50 3	50 6	53 5	48 5
54	50 5	50 5	53 6	48 6
57	50 5	50 5	53 7	48 6
60	50 4	50 6	53 6	49 0
63	50 2	50 4	53 5	49 0
66	50 5	50 0	53 7	48 7
69	50 7	49 8	53 7	48 6
72	50 8	49 7	53 7	48 4
75	50 7	49 3	53 9	48 5
78	50 7	49 4	54 0	48 6
81	51 1	49 2	53 8	48 4
84	50 8	49 3	53 7	48 0
87	50 6	49 4	53 6	48 3
90	50 6	49 4	53 7	48 2
93	50 4	48 9	53 5	48 4
96	50 5	49 6	53 2	47 7

Table 37. Heart Girth Measurements for Determining Body Weights of Dairy Cows*

HEART GIRTH	BODY WEIGHT	HEART GIRTH	BODY WEIGHT	HEART GIRTH	BODY WEIGHT	HEART GIRTH	BODY WEIGHT
Inches	Pounds	Inches	Pounds	Inches	Pounds	Inches	Pounds
26	80	42.5	248	59.5	622	76.5	1,263
26.5	82	43	257	60	637	77	1,285
27	84	43.5	266	60.5	652	77.5	1,308
27.5	86	44	275	61	668	78	1,331
28	89	44.5	284	61.5	684	78.5	1,354
28.5	92	45	294	62	700	79	1,377
29	95	45.5	304	62.5	716	79.5	1,400
29.5	98	46	314	63	732	80	1,423
30	101	46.5	324	63.5	749	80.5	1,446
30.5	104	47	334	64	766	81	1,469
31	108	47.5	344	64.5	783	81.5	1,492
31.5	113	48	354	65	800	82	1,515
32	118	48.5	364	65.5	817	82.5	1,538
32.5	123	49	374	66	835	83	1,561
33	128	49.5	384	66.5	853	83.5	1,584
33.5	133	50	394	67	871	84	1,607
34	138	50.5	404	67.5	889	84.5	1,630
34.5	143	51	414	68	908	85	1,653
35	148	51.5	424	68.5	927	85.5	1,676
35.5	153	52	434	69	947	86	1,699
36	158	52.5	445	69.5	967	86.5	1,722
36.5	163	53	456	70	987	87	1,745
37	168	53.5	467	70.5	1,007	87.5	1,768
37.5	174	54	478	71	1,027	88	1,791
38	180	54.5	489	71.5	1,048	88.5	1,814
38.5	186	55	501	72	1,069	89	1,837
39	192	55.5	513	72.5	1,090	89.5	1,860
39.5	200	56	526	73	1,111	90	1,883
40	208	56.5	539	73.5	1,132	90.5	1,906
40.5	216	57	552	74	1,153	91	1,929
41	224	57.5	565	74.5	1,175	91.5	1,952
41.5	232	58	579	75	1,197	92	1,975
42	240	58.5	593	75.5	1,219	—	—
		59	607	76	1,241	—	—

* Courtesy U.S.D.A. Bureau of Dairy Industry

as below normal, normal, and above normal reveals evidence of a slight relationship between the size of animals at birth and at maturity There are, however, striking exceptions to this observation, and the most that can be said is that while there seems to be a slight tendency toward a direct relationship between the size of animals at birth and maturity, individuals show such wide variations that little practical importance should be attached to this point

Breed The influence of breed on the growth and development of heifers is well illustrated in Tables 35 and 36 When one studies the two extremes, the Holstein and the Jersey breeds, the facts shown may be summarized as follows the rate of growth in skeleton by the two breeds is practically the same from birth to twenty four months but it is greater by the Holsteins from then on The rate of gain in weight from birth is somewhat greater by the Holsteins There is a well marked breed characteristic in reference to age at maturity The Jersey reaches maturity in skeletal growth between three and four years of age, the Holstein between four and five years The maximum weight is reached by both breeds about two years after the growth of the skeleton ceases

Management The management of heifers during the growing period may have an adverse affect upon the final size of the animal but is usually adequately controlled by the herdsman Animals exposed to inclement weather or stabled in dark, poorly ventilated or unhealthy quarters or those infested with lice, will usually be back ward in growth and susceptible to disease

Feeding The inherited capacity for growth and the way an animal is fed are closely related the former being largely dependent on the latter Proper feeding can only give inherited growth capacity full play, but neither can succeed without the other The capacity to grow will be suspended when adequate food is lacking, but on the other hand no amount of food can force an animal to grow beyond its predetermined size, and as a general principle when the stimulating and inhibiting hormones attain equilibrium at maturity, heavy feeding cannot disturb it

Influence of Nutrition on Size of Animals It is well known that the rate of growth and age of maturity of an animal are

hastened by liberal feeding and delayed by scant feeding, and that nutrients fed in the proper amounts and proportions make it possible for an animal to grow to the full extent of its inheritance, while nutrients fed in insufficient amounts may cause the animal never to reach the full development potential of its inheritance.

Table 38. The Effect of Light and Heavy Feeding on Height and Weight of Heifers

AGE	HOLSTEINS		JERSEYS	
	Heavy-fed	Light-fed	Heavy-fed	Light-fed
Months	Height in Centimeters	Height in Centimeters	Height in Centimeters	Height in Centimeters
1	76 7	75 6	70 1	71 6
6	103 4	96 7	92 7	92 3
12	117 8	106 3	108 8	102 5
18	125 4	115 3	116 6	110 6
24	130 1	121 6	121 8	116 3
36	133 7	126 9	125 1	121 9
48	134 9	129 5	125 7	123 0
60	135 9	130 3	125 9	123 0
Total increase	59 2	54 7	55.8	52 4
Months	Weight Lbs	Weight Lbs.	Weight Lbs.	Weight Lbs.
1	113	104	66	87
6	418	292	248	245
12	659	404	463	363
18	891	569	708	495
28	1,036	745	842	664
40	1,070	883	884	743
54	1,119	968	907	822
66–78	1,265	1,113	975	851
78–90	1,191		1,006	922
Total increase	1,078	1,009	940	835

An experiment conducted at the University of Missouri[1] in which thirty-nine purebred heifers of the Holstein, Jersey, and Ayrshire breeds were used, gave results on the influence of liberality of the ration and age of calving on the rate of growth and size of dairy heifers. The results bearing on the effect of the liberality of the ration on weight and skeletal growth are given in Table 38.

[1] Missouri Research Bulletin 31 and Missouri Bulletin 135.

The heavy-fed groups received whole milk and practically all they would consume of a grain mixture composed of corn and oats with alfalfa hay for roughage The light-fed group received skim milk during the first six months alfalfa hay and in some cases pasture, but no grain up to the time of calving After calving, both received the same ration, which was the one fed to the milking cows in the herd There seems no doubt that all requirements of the ration for growth were met in both groups, and that the only difference of importance was in the amount of total nutrients, although the amount of protein may have been involved to some extent

The sudden spread in growth between the heavy- and light-fed groups at about the age of six months can be attributed to the fact that milk was dropped from the ration at this point, and the light fed group from then on received roughage only, until first parturition

The difference in the height of the two groups increased gradually until the maximum was reached at nineteen months for both Jerseys and Holsteins From that point the difference became less marked The figures show that the heavy-fed groups more nearly approached the normal for the breeds The light-fed groups, because of the low ration which they received when young, never reached normal size This would indicate that the conditions of nutrition during growth may result in the size at maturity being below normal, and that high nutrition increases the rate of growth to a considerable extent but cannot stimulate growth beyond the maximum inheritance of the animal

Recovery from Retarded Growth Observation has shown that there is a strong tendency to compensate for adverse conditions which have retarded the growth of the animal and kept it below normal There are two ways in which recovery may take place (1) by an increase in the rate of growth after the period of adversity is passed, and (2) by prolongation of the period of growth When an animal which has been retarded because of a poor ration is given a good ration, the tendency is strong to use a very large amount of food and to make a growth in excess of the normal rate with a tendency to approach the normal size On the other hand, a well fed animal which has made growth above the normal tends to show a marked

retardation when conditions become less favorable. Conditions which may cause a growth above normal for a group of animals previously fed a poor ration may cause a growth below normal for a group that is above normal as a result of a period of high nutrition.

The second method of recovery from a stunted condition is by the prolongation of the period of growth. Heavy-fed animals tend to reach maturity at a comparatively early age, while the light-fed animals grow more slowly and continue to grow for a longer period of time until a more advanced age has been reached. If the retardation was not too severe the light-fed animals may completely recover but if the retardation, especially in skeletal growth, has gone too far, the animal will never reach the normal size.

Whether or not stunting has any deleterious effect on the animals' later welfare has never been fully determined. There is some evidence that milk production of animals fed a light ration is not lessened unless the retardation affects the constitution and vital organs of the animal. The data seem to indicate that milk production at least is maintained even though the animal may never reach her full inherited size. Of course, the production of milk throws an enormous strain on a cow, and any preliminary system of management which would impair the proper functioning of her power to reproduce and to produce a generous quantity of milk would, in the end, result in a loss to the breeder. The general conclusion is that dairy animals should be fed in such a way that they develop normally, not becoming either too fat or too lean.

Influence of Ration on Dairy Quality. In comparing the production of light- and heavy-fed groups at the University of Missouri, it is well to remember that in the first lactation the latter have a decided advantage because of being in a much better physical condition. After freshening, both groups of heifers received similar feed and since one is interested in the ultimate capacity of the cows to produce, a comparison of the second lactation period of these same groups is given in Table 39.

It will be noted that the ten light-fed Jerseys averaged 285 pounds of fat, while eight heavy-fed ones averaged 228 pounds. The difference in the Holsteins and Ayrshires, while both in favor of the

FIG 52 The influence of the ration on the size and conformation This Holstein heifer one year old weighed 396 pounds wh ch is only 70 per cent of normal. She received only skim milk and hay—no grain

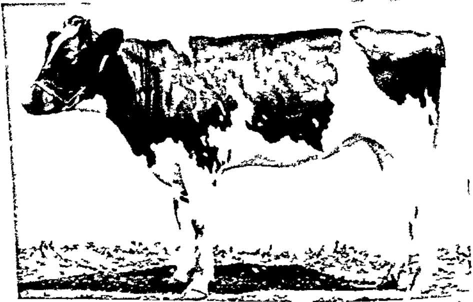

FIG. 53 Influence of rat on upon size and conformation. This Holstein heifer one year old and a half s ster to the one in Fig 52 weighed 730 pounds, which is 130 per cent above normal She received whole m lk to six months of age and all the grain and hay she would consume This is an extreme in overfeed ing as is Fig. 52 in insuff cient feed ng.

fed on ordinary rations. The light-fed group, on the other hand, appeared angular in body with a far more pronounced development of the middle. However, the heavy-fed animals began to show more angularity beginning about three months before freshening; by calving time the round appearance of the body had disappeared to a considerable degree, and they began to take on the appearance of typical dairy cows.

In conclusion, it may be said that the size of the barrel of a cow when mature has no relation to the way she is fed during the growing period. A heavy ration results in more rapid growth with a tendency to coarseness of bone and body, which is not lost when mature. The roundness of the body of heavy-fed animals disappears at about the time of freshening.

Influence of Ration on Sexual Maturity. In the experiment at the University of Missouri, the effect of heavy feeding was to advance the age of sexual maturity. The heavy-fed Holsteins first came in heat at the average age of 261 days while the light-fed ones averaged 373 days, a difference of 112 days. The heavy-fed Jerseys were sexually mature on an average of 76 days earlier than the light-fed ones.

Influence of Ration on Breeding Quality. The experiment at the University of Missouri indicated that even though the heavy-fed heifers were in some instances excessively fat, there was little difference between their breeding ability and that of the light-fed ones. This is different from the common belief that when heifers are excessively fat, difficulty in breeding will result. It should be kept in mind, however, that this might not be true in the case of older cows that are allowed to become fat.

Gestation. A popular misconception has long existed regarding the effect of gestation on the growth and development of heifers. The common belief was that the development of the fetus resulted in a severe drain on the nutrients and materials of the heifer's body, which was reflected in a slowing down of her growth. Gestation, however, has been shown to have very little effect in slowing down the rate of growth, so slight that for all practical purposes it may be entirely ignored.

light-fed heifers, are so close as to be of no special significance In the entire experiment, the nineteen light-fed heifers averaged 258 pounds of fat for their second lactation, while the eighteen heavy-fed ones averaged 227 pounds It might be of interest to know that eight of the eighteen animals in the heavy-fed group were sold after the experiment as being below the standard of the herd and five of the nineteen animals in the light-fed group were considered below standard Just how much of this difference was due to the heredity of the animals and how much was due to the method of feeding is impossible to know It should be stated that some of the best cows, as evidenced by their subsequent production, were in the heavy fed

Table 39 Milk and Fat Production Second Lactation

GROUP	BREED	NUMBER	LBS MILK	LBS FAT
Light fed	Jersey	10	5369	285
Heavy fed	Jersey	8	4393	228
Light fed	Holstein		699	229
Heavy fed	Holstein	8	7246	227
Light fed	Ayrshire	2	5864	236
Heavy fed	Ayrshire	2	5772	229

group This would indicate that heavy feeding does not necessarily injure a cow, even if excessive and prolonged to the age of three years before first calving The general conclusion is that heredity is the chief factor in determining the milk-producing quality of cows

Influence of Ration on Type The effects of feeding on the type of an animal can been seen in the illustrations given Fig 50 shows the mature appearance of a cow raised on the light ration and which calved early Figs 51 and 53 are heifers that received the heavy ration during the period of growth and Fig. 52 is one that received a light ration Besides being larger, the animals that were fed the heavy ration showed a coarseness, especially in the head, not found in the animals given the lighter ration The well fed heifers were smooth and round in body with tops and underline almost parallel but without the paunch development characteristic of heifers

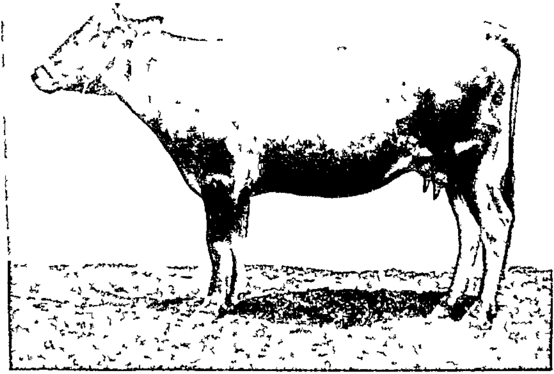

FIG. 50 The combined effect of early calving and a light ration At three years of age she weighed only 622 pounds She calved at twenty three months A light growing ration and early calving are the most common causes of small animals in the ordinary herds

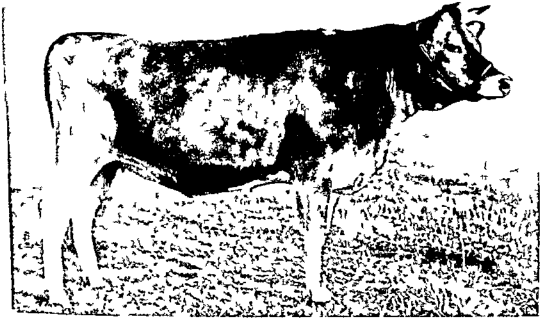

FIG. 51. The combined effect of late calving and a heavy ration Such a practice leads to coarseness about neck throat and shoulders

Experiments have shown that the amount of dry matter contained in the fetus and its accompanying fluid and membranes is very small A Jersey cow produces a total of only 15 to 20 pounds and a Holstein 20 to 25 pounds of dry matter in the fetus and accompanying fluids and membranes On the dry matter basis, a Jersey calf is equivalent to from 110 to 170 pounds of Jersey milk and a Holstein calf is equivalent to the dry matter from 200 to 275 pounds of Holstein milk It is true, however, that there is considerably more calcium and phosphorus in the calf's body than would be found in the amount of milk listed above

Pregnant animals shortly before parturition will outweigh open animals of the same age which have received the same ration Weights taken following parturition show little difference between animals of the same age that have developed a fetus and ones that have not In brief, it may be said that gestation has practically no effect upon the rate of growth of heifers This is shown in Fig 54

Lactation While gestation itself has very little effect upon the growth of heifers, lactation which follows gestation does have a very pronounced influence

(*a*) *Effect on growth* The extent to which milk secretion taxes the animal is seldom realized A comparison with a steer on full feeds makes the facts more impressive A steer making a very satisfactory gain of 2 pounds a day is adding dry matter to his body at the rate of 1 5 pounds daily A cow producing the very ordinary amount of 30 pounds of milk daily is producing 3 75 pounds of dry matter in her milk, or more than twice that found in the gain made by a steer on full feed

As was shown previously, the milk which a good heifer produces during four or five days contains as much dry matter as was needed during nine months to grow the fetus The only source of supply for this material is the food she consumes, and the heavy producers are sometimes forced to draw on their body tissues to supplement their feed During the early stages of lactation the stimulus to produce milk is so insistent in well bred dairy heifers that it takes precedence over the other demands of the body This results in a temporary

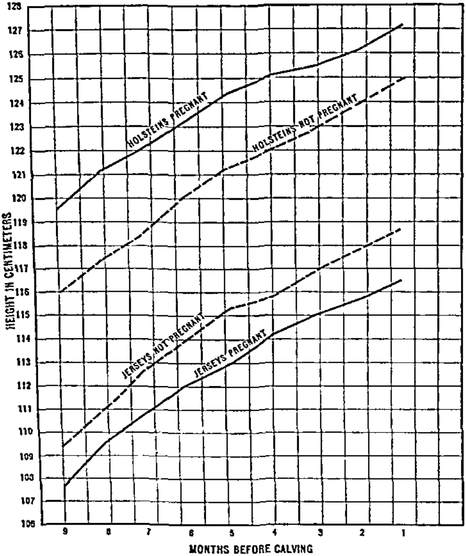

FIG. 54 The influence of gestation upon skeletal growth Pregnancy has very little effect upon the growth of dairy heifers *Gestation is not a severe tax upon* the mother, as is often assumed

check on growth and may be reflected in the ultimate size of the animal

To illustrate the effect of lactation, weights and measurements on two groups of heifers are here cited (Figs. 55 and 56). The groups were bred so that the late-calving heifers would drop their first calves at the same age that the early-calving groups came fresh the second time. Fig 55 shows the results with two groups of Holsteins, one of which calved early and the other late. One month before the

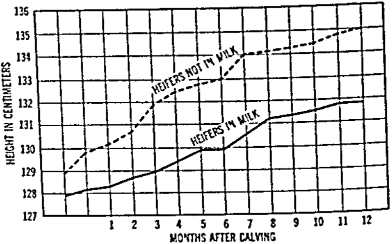

FIG 55 The influence of lactation upon skeletal growth The figure represents results from two groups of Holsteins One month before calving the pregnant group averaged 1 centimeter less in height than the nonpregnant After twelve months in milk the same group was 3 2 centimeters below in height. In contrast to pregnancy, lactation exerts a strong influence upon growth

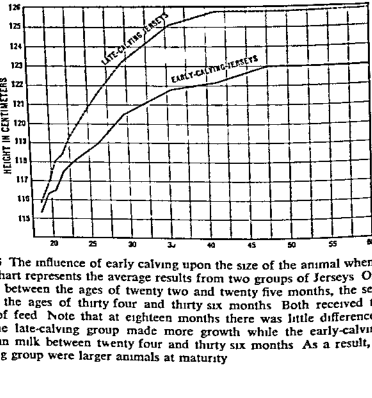

FIG 56 The influence of early calving upon the size of the animal when mature This chart represents the average results from two groups of Jerseys One group calved between the ages of twenty two and twenty five months, the second between the ages of thirty four and thirty six months Both received the same kind of feed Note that at eighteen months there was little difference in size, but the late-calving group made more growth while the early-calving group were in milk between twenty four and thirty six months As a result, the late-calving group were larger animals at maturity

early groups calved the late-calving group averaged 1 centimeter more than the early-calving group. After the early-calving group had been in milk for twelve months, the difference between the groups was 3.2 centimeters in favor of the late-calving group. The difference in the gain in weight was even more pronounced. Fig. 56 carries the study until maturity, showing that the early-calving animals never

Table 40. Influence of the Age of First Calving upon the Growth of Dairy Heifers

AGE	LIGHT-FED JERSEYS		HEAVY-FED JERSEYS		HEAVY-FED HOLSTEINS	
	Early-calving *7 Animals*	Late-calving *5 Animals*	Early-calving *4 Animals*	Late-calving *5 Animals*	Early-calving *4 Animals*	Late-calving *5 Animals*
MONTHS	Height Centimeters	Height Centimeters	Height Centimeters	Height Centimeters	Height Centimeters	Height Centimeters
19	111 1	113 6	119 5	118 1	126 5	127 3
60	121 3	124 6	124 7	127 2	134 1	137 6
Total increase	10 2	11 0	5 2	9 1	7 6	10 3
MONTHS	Weight Lbs.	Weight Lbs	Weight Lbs.	Weight Lbs.	Weight Lbs	Weight Lbs
19	504	524	759	732	942	922
66	866	895	889	984	1,214	1,299
78	865	928			1,221	1,280
Total increase	361	404	130	252	279	358

do reach the size of the late-calving. The continued effect of early calving is shown by the data in Table 40. Without exception, the early-calving groups were smaller in size and lighter in weight at maturity than those calving late, despite the fact that two of the three latter groups were lighter and one smaller than the former group at nineteen months of age. In summary, heifers which calve at an early age are generally smaller when mature than those which calve for the first time after they are more mature.

(*b*) *Effect of age at first calving on type.* As has already been stated, the question of type is closely connected with size, and there

is a general belief that early calving tends toward a more refined, feminine type of animal Early calving does influence the size, and the measurements and observation of the experimental animals at the University of Missouri showed that in most cases, animals that had calved at the age of twenty to twenty-four months had a more refined, feminine appearance and were smaller in size than those of the same breed calving a year later While no attempt was made to apply the scorecard to the individual animals, it is believed that on the average those calving at an early age would have scored somewhat higher at maturity than those that freshened a year later The development of the milking organs, as far as size and shape were concerned, however, did not seem to bear any relation to the age at first calving

(c) *Effect of age at first calving on dairy qualities* The question of the relation of age at first calving to the later production of the heifers is one of considerable interest It has a very practical application to many dairy farms On many farms, the dairyman is interested in having the heifers freshen in the fall of the year, not only because animals that freshen in the fall usually produce a little more than those that freshen at other times of the year but because of the fact that the base for the year is usually set during this period When the cows freshen in the fall, their heifers freshening in the fall will be approximately two years of age when they freshen Otherwise, they must be held over for a year and would be three years old at freshening This would, of course, mean an extra year of feed before they bring in an income, during this time the ones that freshened at two years would be milking and producing an income

It has been shown that heifers that are well grown and somewhat mature will produce more milk during their first lactation than heifers which freshen at a younger age The question of what difference there will be in the lifetime production is of more practical interest. A study made at the Wisconsin Station,[2] the results given in Table 41, shows the average amount of butterfat produced by cows freshening at different ages for the first five lactations and their age in months at the end of that period

[2] Proceedings, American Society of Animal Production 1936.

The results of this study show that the early-freshening animals did not produce as much during the first lactation period as did those that freshened later; even at the end of five lactations they were slightly under the later freshening cows in butterfat production, but

Table 41. Butterfat Production for Cows of Different Ages at First Calving

AGE AT FIRST CALVING	NUMBER OF ANIMALS	LBS OF BUTTERFAT					TOTAL FOR 5 LACTATIONS	AGE AT END OF 5 LACTATIONS
		Lactation						
		1st	2d	3d	4th	5th		
(Months)								(Months)
18–21	10	266	363	383	422	434	1868	84
22–23	14	335	353	433	439	403	1963	86
24–25	56	330	360	402	406	414	1912	84
26–27	58	311	333	395	415	421	1875	87
28–29	36	327	360	399	399	415	1900	89
30–31	15	355	352	403	427	429	1966	92
32–33	24	372	365	414	425	423	2000	96
34–35	23	333	417	449	457	392	2048	98
36–42	17	372	399	426	428	391	2016	103
Mean		331	362	408	419	414	1934	

the difference was not great and they were still several months younger. The production of each group taken to eighty-four months of age is shown in Table 42.

This table indicates that, except for those freshening at ages under *twenty-one months, the animals calving younger gave a higher total*

Table 42. Age at First Calving and Total Production of Butterfat to Eighty-Four Months of Age

AGE AT FIRST CALVING	PRODUCTION TO 84 MONTHS OF AGE	AGE AT FIRST CALVING	PRODUCTION TO 84 MONTHS OF AGE
	Lbs Butterfat		Lbs Butterfat
18–21	1870	30–31	1720
22–23	1930	32–33	1550
24–25	1910	34–35	1540
26–27	1810	36–42	1490
28–29	1760		

production to eighty-four months than the older groups Since this study did not go beyond the fifth lactation, it does not show the relationship with lifetime production nor with longevity There are some who believe that the late-calving animals do not live as long as do the early-calving group

The results of a study at the University of Missouri of animals that freshen at different ages are shown in Table 43 Seventy Jerseys and twenty-five Holsteins were included This table shows that there was a decided disadvantage for a Jersey heifer to calve under twenty-four months, while nothing seemed to be gained by allowing her to

Table 43 The Relation of Age of Freshening and Fat Production

AGE AT FRESHENING	FAT PRODUCTION FOR 3 LACTATIONS
JERSEYS	
Under 20 mos	207 lbs
24–30	260
30–32	328
HOLSTEINS	
Under 24 mos	225
24–30	307
30–36	266

reach an age of more than thirty months It would appear, also, that there is no advantage in having Holsteins freshen before they are twenty-four months of age or after they are thirty months of age

Taking into consideration the question of economy, the best course is to have a heifer well developed in size and maturity when she freshens The way a heifer is fed and managed during her early life has a great influence on her maturity An animal receiving a liberal grain ration during her early life is just as mature at twenty-four months as is one raised on hay alone at thirty months, but the animal which freshens at twenty four months will have six months' earlier production than the one that freshens at thirty months, and

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the milk that she produces during these six months would probably more than pay for the extra feed she would consume.

Combined Effect of Lactation and Nutrition. The amount of feed used and the age of first calving both exert an influence on the growth of an animal and on her size at maturity. By combining liberal feeding with late calving the animal is given the optimum conditions for quick and maximum growth. On the other hand, a combination of early calving with light feeding will result in slow development and size under normal in the mature animal.

Data from the University of Missouri experiment showing the results of this combination of factors are given in Table 44 and illustrated in Fig. 57.

These heifers, beginning at practically the same size at six months, showed a constantly increasing difference in height. This amounted to 6.3 cm. when they were forty-eight months of age. It should be kept in mind that the light-fed early-calving group received an ample ration after first parturition. If it has been deficient either in quantity or quality during lactation, it is certain that the results would have been even more marked. While heredity may in some cases be the limiting factor in explaining the numerous undersized cows seen on many farms, it is believed that the most important cause of small size is a combination of early calving and a scanty ration during the growing period.

Effect of Feed upon the Development of Udder. The development of the udder and milk production are controlled by certain hormones and as a rule are not under the control of the feeder.

The stimulation to produce milk is an inherited quality, and in cows of high milking inheritance it is so insistent that the animal in early lactation will produce milk even at the expense of her own body tissues when the supply of nutrients in the ration is insufficient for both milk and body maintenance. It is now known that the development of the udder and the milk producing ability of an animal are due in a considerable extent to an inherited ability to produce certain important hormones and to react to the stimuli which they furnish. The action of these hormones has been discussed elsewhere,

Table 44 Heavy Rations and Late Calving versus Light Rations and Early Calving

AGE	HEAVY FED LATE-CALVING JERSEYS, HEIGHT	LIGHT-FED EARLY-CALVING JERSEYS, HEIGHT
Months	Centimeters	Centimeters
6	94 7	93 1
9	105 0	97 9
12	110 6	103 9
18	117 1	110 3
24	122 0	114 0
30	124 6	116 1
36	126 1	118 9
48	126 9	120 6

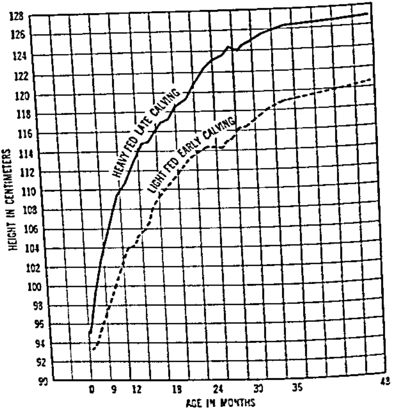

FIG. 57 The combined influence of light feeding and early cal ing upon skeletal growth of Jerseys. The light fed, early-calving group was 1 6 cm below the other at six months while at forty-eight months, when skeletal growth for Jerseys is practically complete, the difference was 6 3 cm The combination of these two factors is a common cause of small cows frequently found in commercial herds

and it is enough to say here that, as far as is known, no metho ordinary feeding has any influence in producing more or less these hormones. Their production is a matter of inheritance. Liberal feeding of young animals enables them to attain the limits of the productive ability which they inherit, but it cannot be set down as a cause for milk secretion. If this were not true, then beef cattle could be fed to produce large quantities of milk, but their use of liberal feeding is to make fat and muscle. Certain hormones have been isolated and fed to dairy animals which cause increased production of milk and butterfat, but at present are not generally recommended. One cannot tell what will develop in the future.

Practical Management of Dairy Heifers. Previous chapters on calf raising have outlined various systems of feeding and management of dairy stock up to the age of six months. This chapter has outlined the effects of different treatments of the growing heifer after reaching the age of six months and up to the time of freshening, and these should receive thoughtful consideration in planning a system of herd management for the young stock.

Feed Requirements for Growing Heifers. The proper feeding of dairy heifers during this period is not very difficult to attain. The heifer has been weaned from milk and special feeds required up to about six months of age, and except for the last few months before she is due to freshen needs only feed for maintenance and growth. The National Research Council has published recommended daily allowance for digestible protein, total digestible nutrients, calcium, phosphorus, and carotene for growing dairy heifers of varying weights. These recommended allowances are given in Table 45. When heifers consume the amount of nutrients recommended in this table, normal growth should result.

The recommended requirements for *digestible protein* are considered satisfactory for normal growth. There is no need to furnish the individual amino acids as the organisms in the paunch of animals of this age will furnish sufficient of the different amino acids. At this age, a deficiency in the amount of *total digestible nutrients* which limits the energy supply more frequently retards the growth of dairy

cattle than does a deficiency of any other nutrient. In practice, the tendency is to waste protein and underestimate the energy requirements

The amounts of *calcium* and *phosphorus* recommended are considered safe amounts to feed Phosphorus is more likely to be deficient under ordinary feeding conditions than is calcium *The ratio of calcium to phosphorus* is thought to be an important factor With various species of animals wide ratios have been shown to depress the

Table 45 Recommended Daily Allowance for Growing Dairy Heifers

BODY WEIGHT	DIGESTIBLE PROTEIN	T D N	CALCIUM	PHOSPHORUS	CAROTENE
Lbs	Lbs	Lbs	Gms	Gms	Mgs
50	0 2	1 0	4	3	6
100	0 4	2 0	8	6	6
150	0 5	3 0	12	8	9
200	0 6	4 0	16	11	12
400	0 8	6 5	20	15	24
600	0 85	8 5	18	15	36
800	0 9	10 0	16	15	48
1000	0 95	11 0	15	15	60
1200	1 00	12 0	15	15	72

utilization of these elements as compared to a ratio of 1 1 or 2 1, but as long as sufficient calcium and phosphorus are provided, the calcium phosphorus ratio can vary considerably for growing heifers without producing undesirable results

In most areas there is usually a sufficiency of other minerals for normal growth, with the exception of common salt. Common salt (NaCl) must either be provided and fed in the grain ration or put some place where the heifers can get what they need In certain areas there may be a deficiency in *iron, copper, cobalt,* and *iodine* and possibly some other minerals The actual requirements for these minerals for growing heifers are not known The iodine may be supplied by feeding of iodized salt, which has been stabilized to retard loss of iodine and contains 0 0076 per cent iodine (0 01 per cent potassium iodide) The feeding of these minerals is discussed in another chapter

Dairy heifers rarely suffer from a lack of any of the vitamins.

cattle than does a deficiency of any other nutrient In practice, the tendency is to waste protein and underestimate the energy requirements

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400	0 8	6 5	20	15	24
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Sufficient amounts of the several members of the *vitamin B co[illegible]* are synthesized by the organisms in the rumen of the growing heifer so that under ordinary conditions the feeding of various members of the vitamin B complex is not necessary. The amount of *carotene* to feed is recommended in Table 45. Carotene is the precursory substance of *vitamin A*, obtained from plant sources. Usually the normal ration of dairy heifers will contain sufficient carotene. Under usual farm conditions adequate amounts of *vitamin D* are supplied by sun-cured roughages or by the action of sunlight. Ultraviolet rays from the sun acting on the pro-vitamin D substance in the skin of cattle and other animals produce vitamin D which can be used in the body. Dairy cattle have been shown to require a dietary source of *vitamin E* but it appears that natural feedstuffs usually furnish adequate amounts of this vitamin to satisfy the needs of growing heifers.

Feeding and Care of Heifers from Six Months to Ten Months of Age. One mistake often made in handling fall-born heifers after the feeding of skim milk or special calf meals has been discontinued is to turn them out to pasture and allow them to rustle for themselves. This mistake should be avoided, as the young animals have not developed the capacity to eat and digest a sufficient quantity of bulky feed to sustain normal growth. Grain feeding should supplement the pasture grass for several months. It may also be a wise precaution to limit the time on pasture for the first few days until they become accustomed to the change of feed. Heifers that have been eating a liberal allowance of hay before they are turned out will more readily adapt themselves to the pasture; but early spring pasture is made up largely of water, and the grain which is fed in addition will pay well in increased growth.

Spring calves which are taken off their special feeds in the fall after the pasture season should also be given some extra grain, but roughage should be fed up to the limit that the animal will consume.

FEEDING HEIFERS FROM TEN MONTHS OF AGE TO THREE MONTHS BEFORE FRESHENING

Summer Feeding. During the pasture season the heifer should be provided with good pasturage. When the pasture is at its best (grass

immature and abundant) heifers over ten months of age will not require any more nutrients than the pasture provides Pasture, when it becomes mature and scanty, will not provide sufficient nutrients for normal growth of the heifers Second growth from meadows or temporary pastures may be used to supplement short permanent pasturage, or if not available the heifers may be fed hay or hay and silage It is desirable to keep a supply of hay available at all times throughout the grazing season in a conveniently located rack so that the heifer can eat hay at will When the pasture becomes very poor, which it often does in late summer, and is supplemented by unlimited good quality hay, heifers will not need any grain, but if the hay is limited or poor in quality and unpalatable, heifers of this age will need three to five pounds of grain in order to maintain normal growth It is a mistake to allow the heifers to become too thin in the fall before bringing them into their winter quarters A little grain fed during that period will save feed later

Winter Feeding Ordinarily the period from weaning to first calving is about eighteen to twenty-four months, which represents two seasons of winter feeding and two of summer feeding or two of one and one of the other Where good pasture is available, it is the most economical method of feeding heifers and should be used whenever possible, but the problem of winter feeding is one that should be given consideration so that the heifer will make normal growth and do this at as low cost as possible

Roughages For winter feeding, good quality hay and silage are to be recommended

Hay The hay should be legume, mixed grass and legume, or grass hay It should be early cut, fine and leafy, and have a good green color *Legume hay* fed alone, however, will not maintain normal growth, as an animal will not be able to eat enough to secure sufficient total digestible nutrients A 600 pound heifer would need to consume almost eighteen pounds of alfalfa hay per day to get the required amount of T D N for normal growth, and if the hay is stemmy she would have to consume even more Nonlegume hay, such as timothy, would provide almost as much T D N as the legume hay but would lack sufficient protein In order to secure sufficient

protein, a 600-pound heifer would have to consume daily almost thirty pounds of timothy hay. To supply the deficiency when the roughage is legume, a home-grown grain can be fed satisfactorily. Two or three pounds per day of corn or corn and oats would supply enough for normal growth, provided the hay is of good quality. When nonlegume hay is fed, three to five pounds of a grain ration containing some high protein concentrate, such as one of the oil meals, would need to be fed in addition to the hay.

Silages. Corn silage or nonlegume hay-crop silage when fed alone has decided limitations, as does nonlegume hay. It is too low in protein and is so bulky that the animal cannot consume sufficient for normal growth. It is low in mineral content in comparison to the legume hay. Hay-crop silage made from legumes would be better in protein and minerals but still the heifer could not consume enough for normal growth. Two to four pounds of a grain mixture should be fed heifers when silage is the sole roughage. Corn or corn and oats would suffice when the silage is legume, but some high protein feed would be necessary when the silage is nonlegume.

Hay and silage. When good legume hay and corn or nonlegume hay-crop silage is fed or when nonlegume hay and legume hay-crop silage are fed, dairy heifers will make normal growth without additional grain. This is only possible when the hay and silage are of excellent quality.

Practical Winter Rations for Dairy Heifers. From the analyses of the foregoing discussion, the following rations are recommended according to the conditions prevailing:

1. When corn or nonlegume hay-crop silage and legume hay are on hand, or can be purchased economically, the following ration is suggested: Silage and alfalfa, clover, cowpea or soybean hay at will; and for animals less than ten months of age, two pounds of grain daily in addition. Corn may be the only grain fed, or a simple mixture of other grains, if the cost is less. For heifers within three months of calving, two to five pounds of grain should be fed daily, depending upon the condition of the heifer, as she should be in good flesh at calving time.

2. When corn silage or nonlegume hay-crop silage, but no legume

hay, is available, a satisfactory ration is silage at will for roughage, with some dry feed such as nonlegume hay or fodder Two to four pounds of concentrates should be fed daily, one half of which should be a high protein feed such as soybean meal, linseed meal, cottonseed meal, corn gluten feed, or corn gluten meal The remaining half may be corn, oats, bran, or any other mixture when cheaper If the hay-crop silage is legume or partly legume, less of the high protein feed would be required, depending upon the amount of legumes in the silage

3 When an abundance of legume hay, but no silage, is on hand, a satisfactory ration is alfalfa, clover, cowpea, or soybean hay at will, and two pounds of corn daily Other grains may be substituted with economy if the cost per pound of nutrient is less than that of corn On a ration of good legume hay, dairy heifers will do fairly well but will not make normal growth It is believed to be economical as a rule, to feed a limited amount of grain in addition to the hay

4 When corn fodder, kafir fodder, timothy hay, or other non legume hay is available, but no silage or legume hay, it is generally best to purchase some legume hay The suggested ration is legume hay one half, timothy or other nonlegume hay one half, and corn or kafir fodder at will With this should be fed three or four pounds of grain mixture consisting of two parts of corn and one part of a high protein concentrate Other feeds may be fed in place of the corn if the cost is less If legume hay cannot be secured, more grain must be fed for even fair results Under these conditions the ration suggested is hay and fodder at will with five pounds daily of a grain mixture composed of one part corn, one part bran, and one part of one of the high protein concentrates

The palatability and bulkiness of a ration are often the limiting factors in the amount consumed and, as a result, in the gains made For example, a ration which meets the requirements as laid down by the feeding standard may be formulated from timothy hay and cottonseed meal, but heifers will not make normal growth on such a ration because they will not eat enough on account of its lack of palatability and its great bulk Usually the lack of total digestible nutrients is the limiting factor for growth but on many farms,

especially in the corn belt, the protein in the ration is the factor which limits growth. A ration which contains a legume hay will seldom be deficient in protein.

Quantities of Feed at Various Ages. Table 46 will serve as a guide to the feeder in using standards for the amount of feed that heifers will consume; but attention is called to the fact that heifers under ten months of age should be fed additional grain. Because of the limited capacity of heifers of this age to eat roughage, some of

Table 46. Amounts of Feeds Consumed at Various Ages

AGE OF HEIFERS	SILAGE AT WILL 1# CORN 1# COTTONSEED MEAL	SILAGE AT WILL ALFALFA AT WILL		ALFALFA AT WILL 2# CORN
Mos.	Silage	Silage	Alfalfa	Alfalfa
	Lbs.	Lbs.	Lbs.	Lbs
	DAILY RATIONS CONSUMED BY JERSEY HEIFERS			
6–12*	15–20	10–15	4–6	7–10
12–18	18–25	12–20	5–8	9–12
18–24	22–30	15–25	7–9	10–14
	DAILY RATIONS CONSUMED BY HOLSTEIN HEIFERS			
6–12*	15–22	10–18	5–8	9–12
12–18	20–28	12–20	7–9	10–15
18–24	25–35	15–30	8–10	14–18

* Heifers less than ten months of age should be fed additional grain

their nutrients must be supplied in concentrated form. The addition of timothy hay to the first of these three rations will improve it, but will not reduce the quantity of silage consumed. Heifers within three months of freshening will need two to five pounds of additional grain in order to put them in good condition at time of parturition.

The Relation of the Winter Ration to Summer Gains. As previously stated, the growing period of a heifer extends over several seasons and when pasture is available, the winter feeding should be so managed that the best results may be secured during the time heifers are on pasture.

Animals that are fed a ration which results in a heavy gain during the winter usually make small gains the following summer on pasture. Those that make normal gains during the winter make

about normal gains the following summer on pasture, while those which make gains below normal during the winter gain in excess of normal during the following summer If, however, the conditions in the winter are too adverse, the gains during the summer will not be sufficient to make up for the small gains made during the winter Figs 58 and 59 illustrate this point and present graphically the results

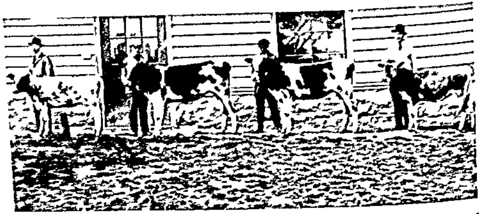

FIG 58 Heifers wintered on corn silage and timothy This group was given a poor ration to observe the effects on gains the following summer Due to the light feeding in the winter they made a gain of only 0 35 pounds per day as against the normal of 0 82 They made practically a normal gain during the summer, however

with three characteristic groups of animals The general tendency here indicated was observed in all groups The best results follow a winter ration of such character that the animal makes a growth near normal, which means keeping them in moderate flesh

Breed as a Factor in Feeding The Holstein heifers seemed to thrive better than the Jerseys on a ration of roughage alone In all comparisons the Holsteins used less energy per pound of gain

Another interesting fact was observed during the summer when the heifers were on pasture Heifers of three breeds from the wintering experiments were turned out together in early summer in a large bluegrass pasture On account of a long continued period of drought the grass became very scanty Before the end of the pasturing season the Holstein heifers became so thin in flesh that it was necessary to feed hay regularly to the end of the season in order to maintain

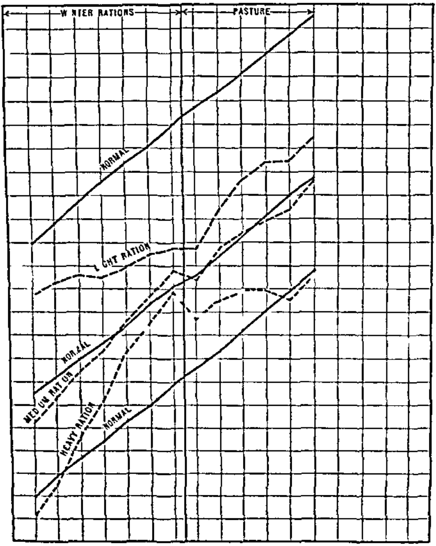

FIG. 59 Influence of winter gains on summer gains Results are shown of animals wintered under three conditions (1) the upper pair of lines represents a group (Fig 58) that made gains far below normal in winter (2) the middle pair represents a group that made normal winter gains (3) the lower pair a group that received a high grain ration and made a gain far above normal during the winter All were turned on pasture together The first group made a good gain but did not reach normal by fall the medium continued to grow at a normal rate on pasture the overfat group made practically no gain in weight during the summer The medium represents the proper plan of feeding

even a moderate state of flesh The Jersey heifers remained in a fair condition without any extra feed while at the end of the season the Ayrshire heifers were in excellent condition—in fact in more than moderate flesh on the grass alone These results rather fairly represent the grazing ability of the different breeds

Age at Which to Breed. The age at which a heifer should be bred depends somewhat on the breed to which she belongs and largely on the way she has been developed Since she will not yield any income until she has freshened, she should be fed fairly liberally so that she may be bred to freshen as near to two years as possible In all herds there are some heifers which mature more slowly than others, and it may be wise not to breed them as early as the others As has already been pointed out, the breeding of such heifers at too early a date may result in undersize, and this in turn is reflected in the producing ability of the animal Many good breeders are feeding their heifers so that they are well grown and can be bred to freshen when they are about two years of age The Holstein and Jersey heifers in the Bureau of Dairying[3] herd at Beltsville, Md , are bred to freshen soon after reaching the age of two years They have found that if the heifer is not undersized, nothing is gained by breeding for freshening at a later date However, when a heifer has not made good growth, then the breeding date is delayed somewhat, since too early calving under those conditions may result in smaller than average cows at maturity

Heifers that freshen early should be well fed during their first lactation period so that their growth will not be stopped In conclusion, well grown heifers should be bred to freshen at as near two years of age as possible and heifers that are undersized should be given several months longer for growth before being bred

Care of Heifers Before Calving The heifer should be in fairly good flesh and in good physical condition at the time of parturition in order to pass successfully the ordeal of calving and to meet the severe demands of a long period of lactation, so that she will continue to grow while she is milking

About three or four months before freshening, she should be brought into the barn and given additional grain If she is in only fair flesh, four or five pounds of grain per day will be sufficient along with liberal quantities of good roughage If she is somewhat thin or the roughage is not of the best quality, she should be fed six to eight pounds of grain per day in order to have her in good flesh at

[3] U S D A Farmers Bulletin 1723 (1952)

calving time. The purpose is not to have the animal overly fat, but the grain feeding should be liberal enough to have her in good flesh and in a good, vigorous, healthy condition at calving time. A good ration can be made from ground corn, ground oats, bran, and linseed or soybean meal, using equal parts of each; or better, two parts of bran to one of each of the others. To this should be added about 2 per cent salt and 2 per cent bone meal. About two weeks before calving, the grain mixture should be gradually changed by dropping out the corn and oats so that during the last ten days only bran and the linseed meal or soybean meal will be fed.

Heifers Should Be Stabled and Handled. At the same time that grain feeding begins, it is well to bring the heifer into the barn with the herd at milking time, and if possible, put her in the stall that she is to occupy after calving. This will accustom her to her surroundings. She should be handled daily during this period in a quiet, gentle manner that will gain her confidence. She should be fed regularly and, if possible, given a chance to exercise outdoors where she will not be molested or worried by other cows. A few days before the calf is due to arrive, she should be put in a well-bedded box stall and watched carefully. Quiet surroundings are always desirable, especially with heifers undergoing the strain of calving for the first time.

Barns for Young Stock. In areas where winters are not too severe, a very convenient and comfortable shelter can be built for young stock at moderate expense. It need not be warm but should be wind-tight and free from draft and dampness. A long shed built of planed boards with battened joints set on a concrete foundation and having a tight roof will serve very well. The interior can be finished roughly into small stalls with hayracks and mangers or at slightly additional cost, wooden or metal stanchions built in and a concrete gutter, edged with twelve to eighteen inches of concrete on both sides, will keep the bedding dry and the animals cleaner. This arrangement facilitates feeding, conserves bedding, and affords good training for heifers. A shed of this kind, fifty by eighteen feet, will accommodate twelve to fourteen animals one to two years of age and allow space for the feeding alley and some feed storage. The

building should be east to west, preferably with the windows along the north and south walls

The Open Shed A very satisfactory shelter can be provided with a partly open shed, closed on three sides but open to the south with access to a yard that is large enough to allow the heifers plenty of exercise This arrangement necessitates the use of more bedding A hayrack and manger at the back or a row of stanchions provide ample means of feeding The animals run loose except when being fed When ample bedding is provided the animals will be comfortable in the open shed in most areas

Severity of climate should govern the type of shelter used, but in common with other farm animals, dairy heifers should be protected from drafts, dampness, cold winds, and storms, when this is done, undue expense to provide warm quarters is seldom justified

CHAPTER XIX

Artificial Breeding

Artificial breeding of farm animals, especially dairy cattle, has been one of the "wonder" developments in the animal field of agriculture. In less than two decades it has developed from a mere speculative dream into a multimillion-dollar industry. It is having a greater practical influence on improvement of dairy cattle than any other single factor or development of this century. Furthermore, its possibilities for future improvement in livestock development are almost unlimited. The National Association of Artificial Breeders reported that over 5 million cows in more than 600,000 herds were bred artificially in 1954.

History of Artificial Breeding. History records that a noted Arabian chief successfully bred a mare artificially in the year 1322. Other reports have been made since that time of successful artificial insemination of various types of domesticated animals in various parts of the world. The Italians showed early interest in artificial breeding and the first scientific approach in this field was probably made by the noted Italian physicologist, Spallinzania, in 1780.[1]

The Russians have been recognized as having done some of the most successful early experimental work in the field of artificial insemination. The cattle breeders and technical workers in Denmark are generally recognized as having been the leaders since the turn of this century in the practical development and use of artificial breeding. It is reported that more than 60 per cent of all dairy cows in Denmark are now being bred artificially.

[1] Perry, *The Artificial Insemination of Farm Animals*, 2d Ed Rutgers University Press, New Brunswick, NJ (1955).

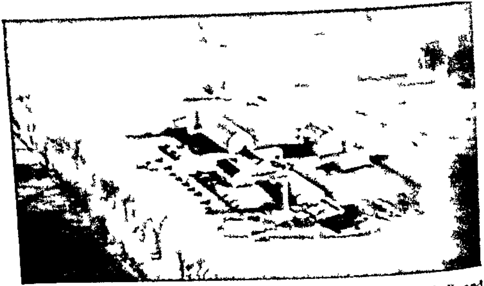

FIG. 60 Modern Artificial Breeding Unit Such a unit can handle 100 bulls and provide state wide service (Courtesy Michigan State College)

tion There are now about one hundred organized artificial breeding associations and units in the United States

Types of Organization There are two different types of organizations in common use for the operation of artificial breeding services they are the farmers co-operatives and the private breeding units Because the Danish development was of the "co-operative" type it naturally followed that the American development should also follow this type Most of the larger and more successful breeding units in the United States today are of the co-operative type especially those serving large areas such as an entire state There is a growing

tendency for many of the smaller units to combine into larger units because of the advantages in such central organization.

Of the nearly one hundred large co-operatives and private smaller studs offering artificial insemination services in 1954, ninety-three were co-operatives, many serving entire states. In Wisconsin over 750,000 cows were bred artificially in 1954. The New York Artificial Breeders' Cooperative reported breeding 1,000 per day, and in intensive dairy states such as New Jersey, better than 40 per cent of the dairy cows are now bred artificially, mostly through co-operatives.

The co-operative breeding services are best suited to serve the mass of average dairymen with medium sized herds. The private studs find their services most suited to the special large purebred or registered cattle breeders who may be interested in a very individual or selective service which permits the individual use of semen from a very special or noted bull of certain breeding or family lines. Such purebred breeders are willing to pay and justified in paying the higher costs necessary for such special or selected semen and the extra services incidental to its use.

Advantages of Artificial Breeding. In the short time since its introduction many distinct advantages have been recognized in artificial breeding over natural breeding. Out of the many advantages which could be noted, the following are of special importance: increased usefulness of superior or "proved" sires; reduction of number of sires necessary; reduction in danger in handling of a single aged bull on the farm; economy in costs of services; availability of superior germ plasm to all dairymen both large and small; and reduction in the spread of disease by the bull in natural service.

In natural service the average herd bull is used on only a few cows each year. If he sires more than fifty calves a year it is unusual, yet he must be fed and singly cared for during the entire year. If he is a superior sire and all his daughters are superior animals the influence of such a bull is still limited to a few cattle and a few farms. Such a bull, however, may be used in a large co-operative artificial breeding association and in a single year be the sire of a thousand or more calves and in a lifetime be the sire of ten to twenty thousand

offspring. Cases are on record of fifty thousand cows being bred to a single sire, and many bulls are in present service in artificial breeding units that are the sires of from two thousand to five thousand offspring. The semen of such bulls can be used in many herds and bring improvement to hundreds of herds and to thousands of cattle and influence the dairy development for an entire area or state.

The average bull in natural service is only used for a few years, because of becoming unruly and difficult or dangerous to handle and also because of having to breed his own daughters after two or three years' service in a single herd. Artificial breeding, on the other hand, permits the selection of the known "proved" or superior sire at the end of his first few years' use in a small herd and his continuous use for many more years in supplying semen to hundreds of herds in the co-operative without danger of too close breeding. Such a bull in an artificial breeding unit is handled under the best safety conditions and equipment and by herdsmen skilled in handling old or unruly bulls. Such bulls are also kept in the best possible physical and breeding condition by expert care and proper feeding so that they remain in efficient breeding condition for many years longer than the average under natural breeding.

Such common cattle diseases as *contagious abortion*, *vaginitis*, *trichomoniasis*, and many others are known to be commonly spread by the bull through natural services. Such diseases are widely spread in the dairy herds of the United States and their elimination has been both slow and difficult if not impossible under natural breeding. Under the prophylactic measures now in common use in all well-managed artificial breeding services the spread of such diseases is no longer common or necessary.

One of the many advantages of artificial breeding is the better control of many of these common breeding diseases and problems.

Semen Collection. The success of any system of artificial breeding depends upon the efficient collection of good live semen and its proper processing and quick delivery and use by the field inseminator in the herds under his supervision. Techniques in efficient semen collection have advanced rapidly in the past few years. The artificial vagina is in almost universal use today in semen collection.

It was first developed and used by the Russians and Danes and has come into its present satisfactory development and modification by many different American technicians. In brief, it is a simple double-walled rubber cylinder about 16½ inches long and about 2½ inches in diameter. It is fitted with a thin soft inner rubber sleeve or tube. This arrangement provides a water-tight space between the outer and inner walls. Warm water at about 110–120° F. is injected

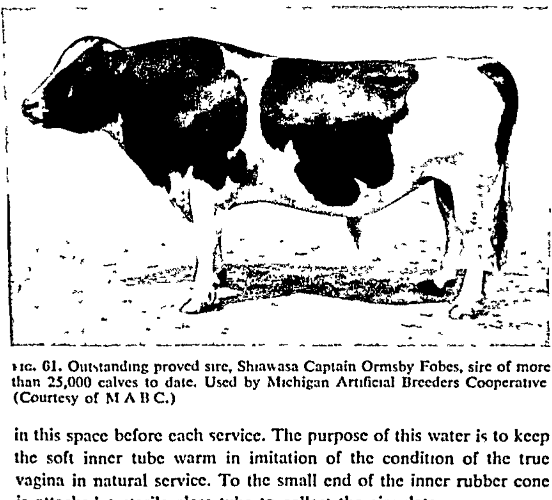

FIG. 61. Outstanding proved sire, Shiawasa Captain Ormsby Fobes, sire of more than 25,000 calves to date. Used by Michigan Artificial Breeders Cooperative (Courtesy of M A B C.)

in this space before each service. The purpose of this water is to keep the soft inner tube warm in imitation of the condition of the true vagina in natural service. To the small end of the inner rubber cone is attached a sterile glass tube to collect the ejaculate.

Most bulls can be easily trained to regular use of the artificial vagina. Its advantages are many: a full normal ejaculate is obtained; it is clean and free from other secretion; the viability of the sperm is higher than from other methods of collection; and the semen collected is immediately ready for processing. This method of semen collection has replaced almost all older methods in earlier use.

Processing Semen The sensitive nature of the sperm necessitates great care and efficiency in the handling, processing, and preparation of the semen for distribution and use A high state of viability is of first importance if a satisfactory conception rate is to be had in the field The semen should be carefully examined immediately for sperm count, color and concentration, and indications of any abnormal conditions, and a later check test for longevity of the sperm should also be made A highly skilled and trained laboratory technician and the use of a highly equipped laboratory are required

After such routine tests have been made the semen is treated with a diluting agent or extender, which greatly expands the volume and prolongs its life so that many more cows can be bred from a single ejaculate of semen Many different types of dilutors have been developed and used The egg yolk-phosphate dilutor and the egg yolk-citrate dilutor have been the most generally used so far, although this is a fertile field for further development, and much research is under way in many places for a still better type of diluting agent which will allow the further expansion of the dilution, increase the preservation, and extend the period of high viability and motility of the sperm The startling new development of the use of frozen semen and the use of homogenized milk dilutors in its processing well illustrate the future possibilities for further research in these areas

The rate of dilution depends on many factors not necessary to be discussed here, but range from 1 to 50 to 1 to 300, but usually is under 1 to 150 It is generally recommended that dilution should not go beyond giving 5 to 10 million sperm per unit of insemination if a high rate of conception in the field is expected

After dilution and cooling the processed semen is placed in special tubes, properly labeled and identified, and packaged in special iced packages which holds the semen at about 40° F while in shipment to the inseminator

Semen Distribution The success or failure of artificial breeding service often depends upon its methods and success in regularly and quickly distributing semen to the field inseminators and member dairymen throughout the area served Many methods are in use in different parts of the United States and by different artificial breeding

units. Where the breeding unit is small or the territory to be served small, or the dairy herds numerous and easily reached, distribution may be made from the main laboratory direct each day by car to the several inseminators. Often the inseminators may work out each day from the central laboratory. Where the unit is large, such as a state-

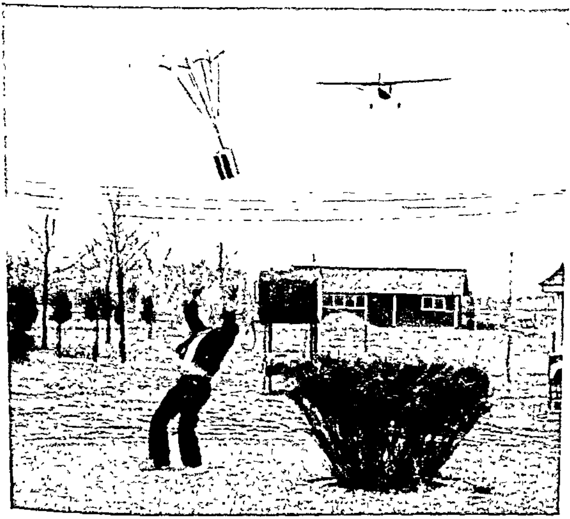

FIG. 62. Distribution of processed and packaged semen by airplane to local field inseminator. (Courtesy Michigan State College.)

wide service, distribution is more often made by mail, bus, and train. Some states such as Michigan, where distances are great or distribution routes not well arranged, have found the use of special air service satisfactory. In this case the semen is packaged in special packages suitable for the purpose and to which a small parachute is attached, and the pilot simply drops these packages at certain

designated spots as he flies over his route They are then picked up by the inseminator before he starts his daily route of herd insemination Uncertain daily flying weather is the greatest hazard to air service

The Inseminator. Much of the success of artificial breeding depends upon the skill and reliability of the inseminator who handles the actual insemination in the dairy herd Usually in co-operative

FIG. 63 The field inseminator on his daily route of service to his local members. (Courtesy Michigan Artificial Breeders Cooperative)

breeding services the dairymen in a locality are organized into a "local" breeding unit This unit should be made up of enough dairymen to have at least 1,000 or more cows in an area that can be covered each day by the inseminator This local hires a well-trained technician who handles all the work of receiving the prepared semen from the central laboratory and taking it out to each dairyman member who notifies him, by phone, as cows come in heat The inseminator groups such daily calls into a route which he covers each day Upon arrival at the farm the inseminator examines each

cow to be bred, identifies her in his records, and inseminates her, using about 1 milliliter of prepared semen. Several methods of insemination are in common use. The uterine and speculum methods have been favored by most operators but the rectal or rectal-vaginal

FIG. 64. Highly skilled laboratory technician and modern well-equipped laboratories are necessary in successful artificial breeding services. (Courtesy Michigan Artificial Breeding Cooperative.)

method is rapidly coming into favor. If the cow inseminated is a purebred, proper records are also kept so that the resulting offspring can be properly identified and registered after birth.

Breeding Efficiency. Artificial breeding to be satisfactory and economical must give results equal to or surpassing natural breeding.

A bull in natural service is usually considered a satisfactory breeder if he settles 60 per cent or more of his first services Artificial breeding services have greatly improved their techniques so that most of them are now well surpassing the best natural services in the conception rate As an example, the Michigan Artificial Breeders Cooperative in its report for 1954 indicated an average of "70 per cent conception for 153,519 first services based on 60–90-day non-returns"[2] This is in line with reports from many other leading artificial breeding units

Frozen Semen and Its Possibilities One of the dreams of all artificial breeding technicians and operators is to perfect the collection, processing, and distribution of semen in such a manner and extent that it can be kept with high viability indefinitely The perfection of methods of freezing semen seems to make this possible In brief, by holding properly processed semen at very low temperatures (—79 below zero C) it may be kept in viable condition for many months or even years

Many thousands of cows have been successfully bred with frozen semen to date Frozen semen introduces many problems yet to be overcome and techniques yet to be perfected before it has wide acceptance for practical daily use The advantages and possibilities are so enormous that it staggers the imagination as much as the idea of artificial breeding itself did a quarter of a century ago

Frozen semen offers the possibility of shipping semen to all parts of the world for the total improvement of all cattle, the storage and use of semen from great bulls years after their death, the reduction of numbers and costs of maintenance and handling of bulls to be kept and necessary for semen production the reduction in the now common wastage of semen, the reduction in present high daily shipping and handling costs, and the possibilities for satisfactory breeding service to all dairymen, even of small herds in isolated areas It offers the hope that it will become one of the great tools for the even more rapid improvement of all dairy cattle of the future

[2] Michigan Artificial Breeders Cooperative Managers Report (1954)

CHAPTER XX

Registered Herds—the Aesthetic and Business Sides of Purebred Dairy Cattle

Why Registered Cattle. In the United States today, of the total of about 38,500,000 head of cattle of all ages kept for dairy purposes only, about 2,570,000 are registered. While this seems but a small percentage, yet all the improvement that has been made in the past came from the limited number of registered cattle called purebred herds. Much of the improvement in the future will continue to come from increasing the number of good registered cattle and through the use of registered bulls with good transmitting ability on grade herds. Dairymen who are creative in their thinking and planning find greater pleasure and interest in working with registered cattle. Such breeders assemble desirable germ plasm and combine it in constructive breeding programs so that it is intensified and multiplied. The breeder of registered cattle enjoys his study of good blood lines and programs of constructive culling and planned mating. He becomes a student of the best breeding practices and a closer student of his dairy herd. For these reasons registered cattle have played and will continue to play a most important part in the continued improvement of the dairy cattle of any country.

What Is a Purebred? The terms *pedigreed stock*, *purebred*, or *registered stock*, as employed in the United States, are used inter-

changeably The term *thoroughbred* formerly in common use—although incorrectly in this connection—has largely given way in recent years to the term *purebred* The term purebred is a misnomer, as applied to cattle Strictly interpreted, there is no such individual A purebred, for purposes of this text, is an animal descended in all lines of its ancestry from animals imported from the locality in which the breed to which the animal belongs had its origin Evidence of such descent must be available in the form of registration records of these ancestors Such animals should more properly be designated as "registered" or "eligible to registry"

REGISTRATION, RECORDS, TESTING

Registration Early breeders of improved cattle are known to have had private records of their breeding operations long before registrations were established for the purpose of preserving these records The first registration of animals in the modern sense began in 1822, when the first volume of the Coates Herd Book for Shorthorns was published in England

At the present time, breeders interested in the various breeds have organizations to keep the records of ancestry in a systematic way and to make these records accessible to the public The books containing these records are generally spoken of as *herd books* When animals are imported, records of their ancestry and of their registration in the herd book of their native country are presented by the importers to the registry association of the breed in the United States If the records are correct and the identification of the animal is established, the registration is made in the books of the American association

An animal born in this country is eligible to registration only when both sire and dam are registered In making application for registration the owner is required to certify to the name and registry number of sire and dam the date of birth of the animal to be registered, the date of breeding of dam and the owner of sire and dam A sketch showing the color markings for identification is required of those breeds such as the Holstein or Guernsey, which are not solid-colored Photographs are now being advocated for this purpose Tattooing is required for Jerseys and Brown Swiss

The expenses of the registry association are met by charging a fee for registration and another for a transfer certificate issued to the buyer when an animal is sold. The fee is greatly increased if registration is delayed until the animal is past a year of age, and with most breeds is more for males than for females. It should be understood that the registration certificate is merely a record of ancestry. It does not in any way certify to the quality of the animal as a representative of the breed to which it belongs, and often uninformed and new breeders have given undue emphasis to registration as a badge of perfection.

Advanced Registration and Official Testing. The present system of official testing which is the basis of Advanced Registration has grown from a small beginning to one of the most important factors in the breeding and development of registered dairy cattle.

With the importation of many highly developed dairy cattle in the decade following 1875, wide public interest was aroused in the exceptional milk and butter production of many of these animals. Certain of the leaders among those interested in these newly established breeds recognized the importance of giving proper publicity to these records. They were not satisfied with the practice of registering animals upon the basis of ancestry alone, and conceived the idea of a second or Advanced Registry to which only those animals would be eligible that showed a high order of merit.

Faults of Early Records. The American Jersey Cattle Club apparently was the first association to publish records of butter production, although the Holstein breeders were not far behind. The Jersey Cattle Club in 1884 inaugurated a plan of publishing butter records covering, as a rule, a period of seven days. The first volume of these tests was published in 1889. These tests were made by the owner according to his own practices and were reported under oath as to their accuracy. Cows making 14 pounds of butter or more in a week were spoken of as tested cows and said to be in the "14-pound list." No special system of requirements as to production and supervision of tests was made by this breed until 1903, when the present Register of Merit was established. Through the activities of Solomon Hoxie at the time of the consolidation of the Holstein and the Dutch-

Friesian Associations in 1885, a provision was made for the establishment of an Advanced Register for that breed This was the first of its kind The animals were tested for milk and butter production under the supervision of the owner Before being admitted to the Advanced Register it was necessary that the animal be inspected by a representative of the Association If the production of milk and fat met the requirements and the animal came up to a certain standard by the score card, she was admitted to the Advanced Register and given a number

Experiment Stations Authenticate Records. The next important step in the development of testing for Advanced Registration was that of calling in a disinterested person to authenticate the record Since agricultural colleges and experiment stations were coming into prominence and had testing facilities, officers of these institutions were generally the ones called upon for this service The Holstein Association in 1894 offered prizes for the best production by different ages, and definitely adopted the policy of having all tests authenticated by an experiment station This came to be known as official testing This plan of asking an experiment station to take the responsibility for the accuracy of the tests has since been adopted for all dairy breeds

Essentially the same plan is followed by the different breed associations, although the minimum requirements for entry vary somewhat and various names are given to the plan of Advanced Registration as shown by the following table

BREED	DATE ORGANIZED	TITLE
Holstein	1885	Advanced Register
Guernsey	1901	Advanced Register
Jersey	1902	Register of Merit
Ayrshire	1902	Advanced Register
Brown Swiss	1911	Register of Production
Red Polled	1908	Advanced Register
Dutch Belted	1912	Advanced Register
Shorthorn	1915	Record of Merit

The classification of animals and the requirements for admission are fixed by each breed association as it sees fit Medals are awarded

in some cases to stimulate interest. The responsibility for the accuracy of the results reported for the period covered by the test is assumed by the agricultural college or experiment station having charge of this work in the state in which is located the animal to be tested. In those states where a considerable amount of testing of this kind is called for, an official known as the Superintendent of Official Testing is generally appointed. The superintendent has the appointment and supervision of the men who do the testing and who are known as supervisors. He also has the right to prepare such rules as he sees fit to govern the conduct of the test, although standard rules have been formulated by the American Dairy Science Association and are in general use.

How Tests Are Conducted. When a breeder desires to test a certain cow or herd, he makes such arrangements with his breed officials as are required by the rules of the association. The breed association then requests the Superintendent of Official Testing in the state where the herd is located to conduct the test for the specified length of time. A test supervisor is sent who watches each cow milked, personally weighs the milk, and makes a test for butterfat, using the Babcock method. The results are reported on suitable blanks and serve as the basis for Advanced Registration of the animal tested. The supervisor in doing the testing is a representative of the college or experiment station having the work in charge. He is subject only to their orders and receives his compensation from them. The breeder is in turn charged by the Experiment Station for this expense.

The growth of official testing among breeders of registered herds has been very rapid. The states in which the largest amount is done are New York, Wisconsin, Michigan, Ohio, Pennsylvania, and Minnesota. In some states more than one hundred supervisors have been employed to handle the work. Official testing is for the breeder of registered cattle, not for the dairy farmer who is interested in milk production alone. For him the Dairy Herd Improvement Association serves the purpose to better advantage.

Purpose of Official Records. In doing official testing the purpose is not primarily that of finding out which cows are profitable

producers, as is the case with the Dairy Herd Improvement Association Before beginning official testing, the owner generally knows himself about how much his animals are producing His purpose is to obtain records of production that will be unquestioned by the public, on account of having been authenticated by an institution in which the public has confidence The purpose of the breeder in having such records is primarily to increase the market value of his stock, both for the future and for the present Official testing has come to serve as the basis upon which most of the breeding animals of dairy breeds are selected It is also the chief factor in determining the value of registered dairy animals With the high price level of earlier years, a single test covering a period of only seven days often added thousands of dollars to the value of an animal

Objection to Short Time Tests When advanced registry testing was begun about 1890, the test period was usually seven days The results were at first fairly satisfactory, since under what may perhaps be called normal conditions the production of a cow for even seven days seemed a fair index of her milking abilities It is well known, however, that in many cases the cow that is capable of making a large seven-day record under normal conditions lacks persistency in milking, and her yield for the year may be considerably less than that of another cow whose seven-day record is far less Even with this chance for misjudging an animal, it is not probable that any serious objection would have arisen to the short-time test had it not been for the opportunity for abusive practices which became so frequent in conducting this test

The serious criticism of the short-time test record in early years amounted to such a complete condemnation and discredit of the test that it is no longer recognized by the various breeders and breed associations The use of the short-time test as a basis of selecting foundation and breeding stock caused many unfortunate experiences and the actual wrecking of several large and important breeding establishments

The Semiofficial Test. The short-time or official test later gave way to the semiofficial test, so called because the supervisor conducted a test only for one or two days of the month throughout the

test period, the herd owner recording the daily milk yield for the other days of the month. This test eliminated many of the abuses of the short-time test and for many years has been considered the standard type of test.

The Herd Improvement Test. The semiofficial test has in turn been giving way to the Herd Improvement Test in recent years. This test is patterned after the semiofficial test as to test procedure but includes the whole herd rather than one or more selected individuals. It gives a much more reliable index of the actual worth of a herd both as to production and for breeding purposes. It makes possible dam and daughter comparisons and has been the means of proving many worth-while sires. When carried on year after year in the same herd, it may be considered the almost ideal type of test. It is gaining in universal esteem and use and may largely displace all other types of testing among registered cattle in the near future.

REGISTERED HERDS AS A BUSINESS

Number of Registered Cattle. Before establishing a business of any kind, a study of the available supply and probable demand for the product would be wise. If this is done for the registered-dairy-cattle business, the conclusion must be that the opportunities are unlimited.

Agricultural statistics. The U.S. Department of Agriculture for 1953 shows 23,996,000 cows and heifers two years old and over. It is estimated that between 9 and 10 per cent or about 2,570,000 are registered. The place and opportunity for the registered business is obvious. These figures show that there is an opportunity for more than double the number of registered dairy cattle to be used to advantage in the United States.

Table 47 gives the number of dairy cattle registered by breeds in 1952.

Registered vs. Grades. The great bulk of dairy products on the market comes at present, and should come in the future, from herds which are of high grade but not registered. The typical herd for nine out of ten farmers producing milk for market is one of well-selected, high-grade cows headed by a registered bull. Many farmers who buy

a registered cow for the first time are disappointed that she is not far superior to their grades If the grade herd has been bred up by the use of registered bulls for several generations, and the inferior producers eliminated, there is no reason to expect that a registered cow will greatly excel the grades

Registration papers do not insure any greater or more economical production than is possible by selected high grades of the same breed

Table 47 Cattle of the Dairy Breeds Registered in the United States in 1952

BREED	TOTAL REGISTERED IN 1952
Holstein	189 690
Jersey	71 513
Guernsey	113 909
Ayrshire	23 208
Brown Swiss	23 099

It is true, however, that on the average registered cows produce more milk than grades of the same breed, partly on account of their purity of blood, but also on account of the fact that they are usually in the hands of men who give more careful attention to individual selection and to proper care and management

The difference in the production of grades and registered cattle under conditions as they exist on dairy farms is shown by results reported by the Extension Service of the Pennsylvania State College from a compilation of records from Dairy Herd Improvement Associations in that state

	NUMBER OF ANIMALS	AVERAGE LBS FAT PRODUCTION FOR YEAR
Holsteins		
Registered all ages	306	299
Grades all ages	707	260
Jerseys		
Registered, all ages	101	308
Grades all ages	306	275

The registered Holsteins surpassed the grades 39 pounds in fat production and the registered Jerseys showed a lead of 33 pounds of fat. This is probably representative for all breeds.

Registered Cattle Always the Seed Stock. Registered cattle are the seed stock for the grade herds that will continue to supply the bulk of the milk products. The registered cattle breeders have the great responsibility of maintaining and improving the breed. In these herds all breed improvement is made, and by the distribution of seed stock, largely in the form of registered bulls, this improvement is gradually spread to the great mass of grade animals representing the substrata of the breed.

Classes of Registered Cattle Breeders. There are two fairly distinct classes of breeders, with other classes ranging between. The first class is the well-established breeder with a high-class herd, and includes the great breeders and the real improvers of the breed. Such herds supply the bulls and the foundation females for the second class. Their stock is mostly too high in price to supply the dairy farmer desiring a bull to head a grade herd. Other breeders of registered cattle supply the market for this class of stock. The second class is composed of those breeders not so well established in the business, or those having herds less valuable in breeding and individual excellence. In this class are the distributors of most registered bulls to the average dairy farmer. The beginner must expect to find himself in this class in the early stages of the development of his herd. The ability of the breeder will determine whether he stays in this class or advances to the point where he is considered a constructive breeder, and animals of his breeding are in demand by other breeders of registered cattle.

Possibilities of a Registered Herd. To a person born with a love for animals, business ability of a high order, and the patience to await results, the handling of registered cattle offers exceptional opportunities. Many examples could be cited. The author at one time purchased four foundation cows for the institution with which he was connected, at the low price of $600. No other females were purchased. At the end of fifteen years it was found that surplus animals had been sold to the amount of $13,800, and that 44 females were

on hand which had an inventory value of $17,000 The value of the milk sold was not included in these figures, but it was sufficient to pay expenses under practical conditions, making the registered herd a splendid investment A Guernsey breeder reports a herd of twenty-one registered animals on hand, all descended in ten years from one cow Forty-one registered calves were dropped on the farm during the ten-year period On the other hand, thousands of dairymen have started in the registered-cattle business only to give up after a period of time, disappointed and in some instances financially ruined Among other causes for their failure usually may be found the lack of that highly important factor called by old-time breeders "the breeder's art"

Successful Breeding a Gradual Development Investigation will show that nearly all successful breeders started in a small way and gradually grew into the business, developing their herd and extending their prestige as a breeder from year to year The registered-cattle business is of slow growth and cannot be forced The young man going into business should not count too much at first on the sales of registered animals He should make his plans with the idea of paying the operating expenses from the sale of dairy products, and not from the sale of breeding stock It requires at least ten years for a registered breeder to become established and for his herd to become known to the extent that his stock is in demand at good prices During this period the breeder must manage his herd with skill and judgment, cull out the inferior animals without regard to pedigree and under no conditions be persuaded to sell his best, and he must give the most careful attention to all details of his business

SELLING REGISTERED CATTLE

Reputation an Asset The reputation of the breeder is no small part of his capital stock and should be most carefully guarded and built up by square dealing and liberal treatment of the buyers A reputation once built up is an asset that remains during the entire lifetime of the breeders and beyond The very foundation of the business of breeding pedigreed animals depends upon the honor and integrity of the men engaged in it A large percentage of the registered

males in use are purchased by correspondence, and the transactions are based upon the reliability of the breeder.

In selling registered livestock it is good business policy to make every effort to have all customers satisfied, even though it may mean considerable expense and being asked at times by purchasers to make adjustments which seem unreasonable. The more successful breeders to a large extent adopt the policy of some of the successful retail stores that "the customer is always right."

Breeders' Business Code. A breeders' association adopted a set of rules to govern the relations between buyer and seller of registered cattle which are worthy of wide adoption They are as follows:

All prices quoted are on the basis of free delivery of the animal to the seller's shipping station.

Animals to be shipped by express are crated free by the seller and the crate returned at the expense of the seller.

All animals shipped are to be provided with a strong halter

Every bull over one year old is guaranteed a breeder provided the buyer's cows are in good condition. If not a breeder, the animal shall be replaced by one equally as good or be returned to the seller and purchase price refunded at the option of the seller. In case of exchange, buyer and seller each are to pay transportation charges one way. If the animal is taken back, the seller pays transportation charges

Every cow or heifer over one year old when sold is guaranteed a breeder and taken back or exchanged on the same basis as for bulls

The seller must call attention to any unsoundness of udder or otherwise, but, if an animal sold as a heifer proves to have a defective udder when she calves, it is the purchaser's loss.

Registry certificate, transfer papers, and tabulated pedigree are to accompany every sale.

In states where provision is made for accredited tuberculosis-free herds it is recommended that all breeders have their herds enrolled. When a buyer tests an animal inside of three months after purchasing and finds the animal tubercular and no other reactors in his herd, the loss falls on the seller, unless he is able to show by a test made within ninety days before the sale that no reactors were in the herd at this time.

Delay on the part of the seller in supplying the purchaser with the registration and transfer papers is the cause of much friction and is inexcusable.

It is a wise precaution for the purchaser to withhold part of the purchase price until registration and transfer papers are secured, except from well known or long established firms

Advertising the Herd A mistake made by most beginners in the breeding business is to expect to find a sufficient market for their surplus animals among their neighbors Experience soon teaches that a wider market than the immediate neighborhood must be found It is human nature to think that conditions at a distance are better than at home, and there is a tendency to go away from home to purchase, even if equally good animals are available close at hand But no livestock breeder ever made much of a success selling breeding stock to his neighbors alone He must in some way get a reputation wide enough to bring buyers from a distance

The breeder of dairy cattle has three ways of bringing his stock to the attention of the public (1) advertising in good agricultural papers, (2) exhibiting at fairs, and (3) making official milk and butterfat records so good that they will attract attention Unquestionably, skillful advertising in good agricultural papers is the most effective means of getting before the buying public Persistent advertising seems to bring the best results A reader confronted weekly with the name of a certain farm or breeder after a while has that name so firmly fixed in his mind that he naturally goes to this place to supply his wants

The breeder who wishes to advertise should select the papers that circulate among the people to whom he can reasonably expect to sell his stock A breeder who has animals that should be placed at the head of registered herds and command the highest range of prices for the breed should usually select the special breed papers Those who have animals that will sell largely to owners of grade herds find the daily journals or the general agricultural papers the best medium

Exhibiting Cattle Exhibiting at fairs with the publicity that goes with it is an effective means of advertising However, there are some serious objections One is the danger in shipping and exhibiting high producing cows in the stage of lactation necessary to make the best impression in the show ring Another, and at times more serious

danger, is that of contracting disease. More stringent rules are being adopted from year to year, and in the near future danger from this source may be mostly eliminated. In the past, many times a herd came back from a fair bringing with it an infection which could only be eliminated by years of effort.

For most breeders the best means of getting before the public is by means of official testing. This is especially true of the small breeder and beginner. The man who has a herd so small that he can look after it himself has an opportunity along this line, except in regard to number of animals to choose from, equal if not superior to that possessed by the large breeder who depends entirely upon employees. Good records become news material and are gladly printed by local papers and even by agricultural papers having a wide circulation. This is the best possible advertising.

Naturally a breeder must have the stock to show when buyers come. When animals are shipped it is very important that they be in splendid condition. When a man receives a high-priced bull calf, his neighbors all come to have a look, and the animal should be one he can show with pride. Farmers often say they do not want the breeding stock they buy to be fat; but fat shows a healthy, growing condition, even with dairy animals, and the calf a little fatter than is really necessary is pleasing to most buyers.

Acquiring a Knowledge of Pedigrees. If one is to become a successful breeder of registered cattle, it is necessary to become familiar with the prominent animals and best known lines of breeding within the breed used. To gain this information and to keep up to date requires constant study. A breeder who is engaged in the business on a considerable scale will do well to purchase a set of herd books and become a member of his breed association in order to secure the volumes as they are issued.

Anyone, with a little study, can make up a tabulated pedigree from the herd books. However, the official records are an important part of the pedigree, and these are obtained from another volume or series of volumes (depending upon the association concerned). Even when the breeder does not feel justified in purchasing a set of herd books, it will be advisable to have a copy of the most recent volume giving

reports of official records at hand. Because many breeders do not feel justified in keeping a full up-to-date set of such records, many pedigree firms who make a specialty of pedigree writing will supply complete pedigrees at small cost. Sale catalogues should be preserved and studied. Attendance at a few high-class public sales, with a careful study of the pedigrees of the animals sold with reference to the selling price, is also an excellent means of becoming familiar with the popular lines of breeding. The breeder should also be a close reader of the special publication or journal published in the interest of his breed.

Public sales and cattle shows also afford opportunities to meet fellow breeders and to widen the scope of one's information regarding his own breed. Any really successful purebred breeder must be able to quote from memory at least the pedigrees of his most important animals.

Naming Registered Cattle. The rules for the registration of pedigreed animals require that no name can be accepted that has already been used in the herd book. This requirement causes some difficulty in selecting a suitable name, when in some associations over half a million animals have been registered. This annoyance may be avoided, and at the same time advertising possibilities realized, by having a suitable plan of naming.

The best plan for naming involves the use of either a certain prefix or a suffix to the name of all animals registered from the herd. The common practice is to select a suitable name for the herd or farm and use this as the prefix or suffix. An example is the word "Pontiac" used as a prefix by a well-known Holstein herd, and the phrase "of Hood Farm" used as a suffix by a Jersey breeder.

A desirable plan involves the use of a prefix indicating the herd, the second name indicating the sire, and the third indicating the individual and generally suggesting some of the ancestors of the animal. In a particular case the herd prefix to be used is "Minnehaha." Offspring of Majesty's Origa, for example, are named Minnehaha Majesty ———— with a third name to designate the individual. The breed organizations recognize the value of such a prefix or suffix and give a breeder the exclusive right to use it in naming registered

animals. In time the public comes to associate the particular name with the herd, and each time the name of an animal appears in print the herd from which it came is fixed in the minds of the reader. Special care should be taken that the name is as short as possible, easy to pronounce and remember. Some breed associations limit all names to not more than thirty letters.

A satisfactory plan to use in connection with a naming system is to give each animal a herd number at birth which is never changed, and to keep all records by this herd number. The animal is more often referred to by number than by name among the attendants.

Rigorous Culling of Registered Cattle. The breeder will be most successful who insists upon individual merit as well as good pedigrees. The breeder building up a herd is often reluctant to discard animals of inferior individuality from his herd when they are well bred and possibly the offspring of some of his best breeding stock. A pedigree, no matter how popular, should never be made the excuse for keeping animals in the herd that are not creditable representatives of the breed. Inferior animals will appear in any herd, but the breeder of judgment does not retain them for breeding purposes, neither does he sell them to others for breeding animals; but he sends them to market, or, if too valuable for slaughter, disposes of them as grades without giving registration papers. The greatest criticism of American registered-cattle breeders is the failure to cull as rigidly and as consistently as they should.

Danger of Fads. Fads frequently develop for certain colors or combinations of breeding which have no real foundation of value. The breeder should avoid the danger of injuring his herd by attempting to follow these temporary fads, although some attention must be given to meeting the popular demands. For example, a black nose may be considered undesirable in registered Guernseys. While this is something of a fad in so far as it has no real significance from the standpoint of the milk-producing ability of the cows, a breeder would be wise to avoid breeding animals with this characteristic, for it may interfere with the sale of his stock.

The Breeder a Good Judge. The breeder should become a good judge of the breed of cattle in which he is interested, and attendance

at fairs when the judging is under way is of material assistance Visits to leading herds, with a careful study of the breeding animals in use, are also worth while

Other Suggestions to Breeders It should be kept clearly in mind that feeding is of equal importance with breeding No herd of cattle, no matter how well bred, will make a creditable showing either in appearance or in production without liberal and intelligent feeding Many of the failures of a registered cattle breeder are clearly due to improper feeding—often combined with the keeping of inferior animals in the herd on account of their pedigrees A suitable system of marking the animals is of great importance, not only because of the danger of mistaking one young animal for another, but because a practice of depending upon the memory of the owner does not tend to inspire confidence in prospective buyers

A system of keeping the herd records is also necessary A form for this purpose has been described in a previous chapter In addition to the book for keeping milk and butter records, a barn book is needed in which information concerning breeding and the birth of calves may be recorded Satisfactory books for these purposes can be prepared by suitable ruling in a blank book or well-designed books may be had from the publishers of dairy journals

The registered cattle breeder must also recognize the importance of keeping his premises attractive The sale of meat animals does not in any way depend upon the condition of the premises where they were grown, except in so far as the presence of disease might be a consideration With the seller of registered cattle the conditions are quite different His premises must be neat well kept, and free from disease They must indicate good management A set of buildings showing a run-down appearance and a general lack of thrift will do more to destroy confidence in the seller than the most active salesman can counteract

Selling by Mail A large share of the business of selling registered livestock especially by those who sell the less expensive kinds including bulls for grade herds is done by mail To sell goods successfully by mail taxes the ingenuity and resourcefulness of the best-

trained businessman. The beginner in the registered-cattle business has much to learn, and he must make a study of the proper methods of handling these details satisfactorily or he cannot long remain in business. The amount of correspondence required to make a sale surprises the inexperienced man. If one sale is made to each five inquiries, the seller should consider he is doing as well as the average. A breeder should provide some office equipment in the form of a suitable desk, a typewriter, filing cases, and well-printed letterheads. Every inquiry should be answered promptly, even if no animals of the description called for are for sale. This is important as a means of holding the good will of possible buyers in the future. Carbon copies of all letters should be kept to avoid disputes over prices quoted and descriptions of animals. The breeder, or someone in his family, should learn to use the typewriter sufficiently to type all letters.

Printed pedigrees an aid to sales. When the animal to be sold is of a class to justify the expense, a printed tabulated pedigree may be obtained in sufficient quantity to meet the probable needs, at a moderate expense. A copy of the printed pedigree which will give all official records in the pedigree is sent to each prospective buyer together with a written description of the animal. When the breeder does not feel justified in having a pedigree printed for each animal offered for sale, he may wish to have printed pedigrees available of his herd sire. In answering an inquiry with these available, it is possible to send a copy of the sire's pedigree, leaving only the breeding on the dam's side to be given especially. Care should be taken to avoid all long, involved statements of ancestry. Some prefer to make out a fully tabulated pedigree written either by hand or with a typewriter.

A plan used by many breeders with satisfaction is to prepare a statement concerning each bull to be sold shortly after it is born. This description is typewritten on thin paper, so that several copies can be made at once. In answering an inquiry, a printed pedigree of the herd sire is sent together with the descriptions of such animals as seem to meet best the needs of the buyer. The following is the form of description commonly used:

HOLSTEIN BULL HERD NO 260

Name Minnehaha Homestead Ormsby

Born July 1 1954

Description About two-thirds white large and vigorous for his age, level rump and good barrel

Sire See enclosed pedigree

Dam Facile Aaggie of Shady Nook Dam has an official record of 23,372 pounds of milk and 781 pounds of fat in one year She was first prize aged cow at the Minnesota State Fair Her daughter, a full sister of the bull offered has a record of 20 001 pounds of milk and 697 pounds of fat as a two-year-old

Tuberculin Test The herd is on both State and Federal accredited lists

Price $350 includes registration and transfer papers and tabulated pedigree f o b St. Paul Photograph and fully tabulated pedigree will be supplied upon request.

For nine out of ten buyers a description of this kind is all that is desired A tabulated pedigree is prepared and a copy sent only on special request When the animal is sold, the tabulated pedigree is forwarded with the registration and transfer papers Females that have been bred should have a signed statement to this effect attached to the official transfer application which is sent to the breed association

The Individual Public Sale There are two classes of public sales individual and consignment A public sale has many advantages and some disadvantages as well Only a large breeding establishment can furnish sufficient animals to justify a public sale except in cases where a herd is dispersed There is always considerable expense in conducting a public sale To make a successful sale, the breeder must be well known and have a reputation for desirable stock that will lead buyers to come some distance to buy Unfavorable weather may nearly ruin a sale Often the prices realized at public sales are better than could be obtained at a private sale At such a time the enthusiasm of the buyers often results in prices much above the going price at private sale When conditions in the business are unfavorable and confidence is lacking among prospective buyers, the reverse is true and the prices at public auction are usually lower than can be received at private sale For the individual, the public

sale has the advantage of concentrating into a short period all the labor of preparing animals for sale, getting the necessary information ready, and attending to the numerous details the sale of breeding animals requires.

The Consignment Sale. The consignment sale may be held by a group of breeders and may be of local character, or a state or national organization may assume the responsibility, giving the sale a state or national scope. The conditions under which such sales are now conducted are usually controlled in a satisfactory manner, insuring fair treatment to the buyer. Care should be taken that the animals consigned are sound and of good quality. By-bidding is forbidden, and a genuine effort is made to conduct the sale in a manner which shall be above criticism The expenses of conducting a public sale are considerable. Consigners to public sales usually pay 10 per cent of the selling price for the expenses of the sale. This covers advertising, the auctioneer's fee, providing of the facilities for the sale, and all minor expenses. The consignor pays all expenses of preparing his stock, shipping to place of sale, and caring for them until they are sold and delivered. Consignment sales sponsored by the county or state breeders' organization have become very popular and successful.

CHAPTER XXI

Care and Management

Importance of Proper Management. It is pointed out elsewhere that the results obtained from a dairy cow depend first of all upon her inherited capacity to produce milk—that is, the efficiency of the machine—and, second, upon how skillfully the machine is used. Skill in using the machine includes, first of all, intelligent feeding, but in addition, the care and attention with which the numerous other details of management are carried out has a large share in the final results obtained. The astonishing milk and fat records made in recent years are due, not to any sudden increase in the capacity of cows to produce milk, but mostly to better methods of breeding and more efficient handling.

Regularity and Gentleness in Handling. The dairy cow is a creature of habit. She easily becomes accustomed to a regular routine regarding feed and care, and any change in this program tends to disturb her and to cause a decrease in milk production. Experience shows that regularity in all details is one of the essential factors in keeping the milk flow constant. Either the grain or the roughage may be fed first, but the same order of feeding should be followed regularly day after day. A cow may be readily accustomed to eating grain before milking, at the time of milking, or following, but she will be uneasy if the same routine is not followed all the time. It is especially important that the milking be done at the same hour, by the same attendant, and under the same conditions as far as possible.

The highly developed dairy cow is inclined to be of a nervous disposition and is easily excited. Furthermore, it is necessary for the attendants to come into close contact with her in feeding, milking,

seasonal character of reproduction has been lost. The herdsman now regulates the time of the year in which the calves are to be born.

Under rather primititive conditions of agriculture, where dairying is somewhat of a side line to general farming, the custom is to have the calves born in the spring. The cows then produce most of their milk during the pasturing season. Under this condition the largest milk flow is produced from pasture which is generally the cheapest feed if the labor of growing winter feed is taken into account. This practice, as a rule, goes with a small average milk production.

After dairy farming has passed through the early stages of development, better accommodations in the way of barns and feed supplies become common, and the cows are expected to continue to produce milk at least ten months in the year. When these conditions are reached, the advantages of having the cows freshen in the fall begin to be recognized.

Advantages of Fall Calving. It is found where good conditions are maintained that cows calving in the fall will produce more milk during the year than those calving in the spring, and that the average fat content will be a little higher. Furthermore, the farmer has more time to give to the cows and to calf raising in winter. It is also of considerable advantage to have the dry period come during the heat of late summer when the weather conditions and flies are unfavorable for milk production. Having cows dry at this time makes possible having them out on the ground in pasture and in the sunshine, which is certainly an aid to health and vitality. Still another advantage is that fall calving brings the highest production at the time of highest market prices.

In studying this subject the author made a compilation of the records of thirty-two cows, each of which had a lactation period beginning in the fall (October to December) and another in the spring (April to June). The results are as follows:

Comparison of Spring and Fall Calving

	LBS. MILK IN YEAR	LBS. FAT IN YEAR	AVERAGE PER CENT FAT
Spring calving	6,451	293	4.54
Fall calving	7,125	339	4.75

the time should be groomed daily When they are on pasture it is not necessary to give them such frequent attention, although it is always desirable The value of grooming is primarily that of keeping the skin of the animal clean, which is necessary for the production of clean milk. Grooming is also desirable for the health of the animal Experimental trials made mostly with cows producing only a medium amount of milk have shown little, if any, increase in milk production due to increased grooming Well-groomed cows look better, however, and add to the pleasure and satisfaction of the attendants, who spend much of their time with them

For general use in grooming cows, a stiff brush is preferred, although an ordinary currycomb is needed when the animal becomes soiled with manure During hot weather it is a common practice in some dairies where water pressure is available to wash the cows by using a hose Cows should never be allowed to stand in a draft or chilly places after being washed In Holland, the cows are washed frequently with the aid of a brush

CALVING

The Period of Gestation The average period of gestation for the cow is 282 days The Breeding Committee of the American Dairy Science Association, after an extended study of many thousands of gestations for the various breeds, suggests the following Ayrshires, 278 7 days, Brown Swiss, 290 8 days, Guernsey, 284 days, Holstein, 278 9 days, and Jerseys, 279 3 days These averages have been supported by many investigators First gestation seems to be about two days shorter than subsequent ones Becker[1] reports from an extensive study of the Jersey herd at the Florida Experiment Station that the gestation for Jersey males averaged 277 9 days, while the gestation for Jersey females averaged 276 5 days

Spring Calving Under conditions of nature, the cow normally gave birth to her young in the spring or early summer, as do wild animals of related species at present Under conditions of domestication, where feed is supplied in abundance the year around and all conditions of physical comfort of the animals provided for, the

[1] Florida State Experiment Station Bulletin 529 (1953)

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These figures show that the thirty-two cows averaged about 10 per cent more milk and 15 per cent more fat during the milking period beginning in the fall Where it is desirable to have a uniform amount of product to market throughout the year, the plan is followed of having the herd bred to freshen regularly throughout the year

THE HORNS

Dehorning For the ordinary dairy herd there is every reason why the animals should be dehorned Before domestication, horns were a useful protection against other wild animals, but horns on a dairy cow of today serve no useful purpose They are responsible for frequent injuries—often serious, and especially to the udder Dehorned cattle may be housed in a much smaller space, and when they are fed and watered together as in the modern pen-type barn, there is a material saving in labor Horns on a bull are extremely dangerous The only cases in which it is advisable not to remove the horns are those of high-class animals which are likely to be used for show purposes and are kept in separate stalls While the scale of points for the various breeds allows only one or two points for horns, a dehorned animal shows to a disadvantage and loses much more than the score card indicates when in the show ring Dehorned animals are occasionally found in the show ring, but the leading show animals are still practically all horned

Methods of Dehorning The best method of dehorning is to use caustic potash on the young calf To use this successfully, the dehorning must be done before the calf is three weeks old, and the earlier the better The hair is clipped away from the small buttons on the top of the head which may be felt and which are the future horns A stick of caustic potash especially prepared for this purpose is then moistened a trifle and rubbed on the spot until the skin bleeds slightly Care must be taken to avoid letting it run down the head, taking off the hair—and even getting into the eyes, with serious results If sufficient caustic potash has been applied, a dent will be felt in the skull after a few days and no horns will ever develop A new caustic, antimony trichloride combined with collodion, is now on the market and is becoming popular in certain sections

The most common method of dehorning is by the use of the saw or clippers. For animals from six to twelve months old, the clippers are recommended, while for the older animals, especially after maturity, the saw is more desirable. Electric dehorners are popular in England and offer advantages where electricity is available. They have been recommended by some authorities in the United States.

Season for Dehorning. The dehorning should be done during the cool weather of spring or autumn. If done in hot weather, immediate means must be taken to keep the flies out of the wound. A good disinfectant must be used after bleeding stops. Pine tar is also in common use, as it will stick on the wound for several days and is a good fly repellant. When taking the horns off with instruments, care must be taken to cut sufficiently close to the head. The rule is to cut from a quarter to half an inch below where the skin joins the horns, leaving a rim of the skin on the horn removed.

A suitable means of securing the animal is necessary. Stocks or a strong stanchion is generally used, and the animal's head further secured by a strong halter. Those inexperienced in this work will do well to observe someone else perform the operation before attempting it. Details concerning methods of tying animals and performing the work may be had from various bulletins on the subject.

Effects of Dehorning. The pain resulting from the operation may be easily overestimated. Careful observation has shown that the dehorning of cows in milk does not materially affect their milk production, even during the first few days following the operation and not at all a few days later.

One experiment station reports a loss of 7 per cent for three milkings, another one pound per day for four days, and still another one-half pound a day for two days. It has also been observed that the disturbance due to dehorning a portion of the herd exerts as much effect upon cows in milk not dehorned as upon those upon whom the operation has been performed.

There are usually in every horned herd of cows one or more that are trouble-makers. The worry, pain, and cruelty that such animals show to their mates are eliminated with the horns, and a quiet contentment of the herd is at once noticeable.

Training the Horns The breeder of registered cattle, especially when in the habit of exhibiting in competition, not only desires that his animals retain their horns, but is interested that they be developed in such a way as to add to the beauty of the animal The horns can be made to grow in almost any shape desired, by the proper use of horn trainers The horn trainer is a metal device so constructed that such pressure may be applied to the growing horn as seems necessary to give it the desired form They may be homemade or purchased from a number of manufacturers

The trainers should be applied when the horns are about two inches long but not before they become set solidly to the head The trainers should be tightened a little every day until the horns assume the shape desired Sometimes when it is desired to have the horns curve in, holes are bored in the ends of the horns and a piece of wire is used to draw the tips gradually inward If the horns are turning up more than desired, sheet lead may be used to weight them The file and sandpaper are used to smooth off rough spots and angles

METHODS OF INDIVIDUAL IDENTIFICATION

In breeding registered cattle it is very essential that some practical system of identifying the individuals be adopted Even if a breeder feels that he can depend upon memory alone, it is not advisable to do so The records of some valuable herds have been lost through the death of the owner, who was the only one who knew the individual animals

The common practice of taking dairy-bred calves away from the dams soon after birth to be raised by hand makes it much more uncertain to depend upon memory to identify these animals than is the case with beef bred cows, where the calf is raised by the mother in the natural way and the owner has several months' time in which to become familiar with the individuals

The Use of Tags When a buyer visits a herd, he receives a much better impression if every animal bears a neat and easily read tag Every calf should be tagged in some manner within a few days after birth and a record made in the herd book to identify the animal It is

important, even in grade herds, to have a permanent mark of some kind that may be used as a means of identification if question of ownership should arise.

There are several methods in more or less general use for this purpose. A common plan is the use of ear tags of various forms, bearing numbers, and, if desired, the name and address of the owner. Some of the forms in use are shown in Fig. 65. The chief objection to these is that they are frequently torn from the ear by being caught in a fence or branch of a tree, and in this way not only is the mark lost,

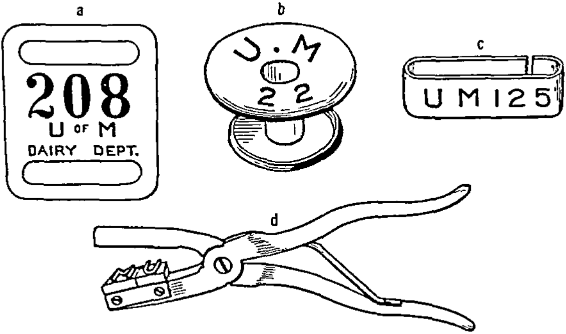

FIG. 65. Devices for marking cattle. *a*, brass tag to go on strap; *b*, *c*, ear tags; *d*, tattoo marker.

but the animal is disfigured as well. An advantage of this type is that it may be removed and another substituted if desired. In inserting these tags, care should be taken not to close them too tightly on the ear, as a soreness may result which leads the animal to rub the ear and tear out the tag. In tagging small calves leave at least one-quarter inch clearance for ear growth.

Other Systems of Marking. Various systems of notching the ear to indicate numbers are also in use. These are satisfactory, except

that the animal is disfigured, and the system must be known in order to read the number The Danish dairymen use this system almost exclusively, their system is shown in Fig 66 Another method in use is to burn the number on the horn or hoof A mark on the hoof must be renewed at intervals, and one on the horn is occasionally lost by the horn's being broken off, it is impracticable also in many herds on account of the practice of dehorning The young calf cannot be marked in this manner Some breeders mark the animals by placing about the neck a brass tag bearing a number on a strap This is especially well adapted for calves

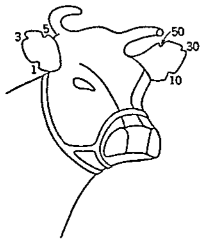

FIG 66 The Danish system of ear marking is much used in northern Europe

Tattooing For use with all breeds having light-colored skin in the ears, the tattoo mark is the most satisfactory of all This consists in using India ink to print the numbers or letters (as desired) in the skin of the ear The instrument for making the punctures is arranged so that any combination of letters or figures may be used They are sold by several manufacturers or can be secured from the Breed Associations In using them, the skin of the ear should be thoroughly cleaned of grease by washing with soap or gasoline The puncture is then made with the tattoo instrument and the tattoo oil thoroughly rubbed in The figures show clearly after a few days, when the wound is healed, and remains permanently

The plan used by many breeders is to identify every calf before it is separated from its mother Each animal is given a permanent herd number, which is recorded, and a strap placed around its neck bearing this number on a brass tag This tag is worn until the animal is nearly mature The tattoo mark is put in the ear as soon as convenient after birth from one week to ten days being the usual time Tattooing while not suitable for identification at a distance, makes it possible at any time to identify the animal positively

SHELTERING COWS

The housing of the dairy cow naturally depends upon the climatic conditions. In regions with long hot summers and little cold winter weather, the main problem sometimes is the protection of the animal from the sun or flies during the heat of midday. Under these conditions sheds of inexpensive construction, open on all sides but protected against insects by means of netting, are used.

When cold weather is experienced during the winter, the question of protection against storm and cold becomes an important one. The most favorable barn temperature has not been determined experimentally, but according to Armsby it is between 40° and 50° F. for well-fed cows and between 55° and 65° for growing animals and animals on maintenance. This is in accordance with practical observations. Experimental work and practical experience have shown that the fattening steer with a surplus of heat in his body does not need much, if any, protection from the cold more than a windbreak.

The cow, however, is not protected by thick layers of fat as is the steer, and she is far more susceptible to cold. Dairy cows and young stock should not be unduly exposed to severe weather, while cold rains and snowstorms are especially to be avoided. Cattle, when well fed, are not so sensitive to low temperatures if protected from the wind and dampness.

The Pennsylvania Experiment Station was one of the first to study the problem of the effect of shelter on milk production. For three winters they compared the feed requirements and milk production of two groups of cows, one housed in a well-built barn, the other in a shed open to the south. These trials showed that the cows kept in the open shed had keener appetites and consumed more roughage than those kept in the closed barn. The group inside averaged only one per cent more milk for the three-year period. The milk yield of the group in the open shed decreased somewhat more rapidly than that of the inside group. The outside group required more bedding but less labor to keep clean.

Prof. J. R. Dice,[2] at the North Dakota Experiment Station, carried

[2] J. R. Dice, North Dakota Experiment Station Bulletin 344 (1947).

on similar trials for twenty years to determine the ability of dairy cows and heifers to withstand exposure and cold

Observations and data proved that milk cows can stand considerable exposure to low temperatures of cold, dry areas The idea that dairy cows receiving an adequate ration need to be kept in a warm barn to be comfortable and to produce satisfactorily seems to be an assumption rather than a fact

In these experiments cows housed in a cold shed required no more nutrients for milk and butterfat production than other cows or the same cows when kept in a standard dairy barn About a third more bedding, however, was required for the open-shed cows, and more trouble with frosted teats occurred when the udders were tightly distended with milk or when udders were pendulous

In these trials, heifers in the open shed consumed more protein and more total nutrients per pound of gain than in the closed shed, suggesting that more energy was needed in keeping the heifers warm A good shelter is definitely recommended for young heifers

Woodward[3] and associates report a similar trial at Beltsville, Maryland, covering three winters In this trial the cows in the open shed used somewhat more feed and produced slightly more milk than those kept in the closed barn The increase in production, however, was not sufficient to offset the extra feed required Slightly more labor and 68 per cent more bedding were required by the open-shed lot There was also the added discomfort of the attendants

Summary In cold climates cows should remain in the barn except for a few hours in the middle of the day when the weather is mild On stormy days or during periods of excessively cold weather cows in milk will do best if kept inside constantly In this connection the use of individual watering cups in the barn is especially to be recommended

An abundance of fresh air is as necessary for the health of the cow as of any other animal and should be provided without fail However, it should be supplied by proper ventilation and not through the walls of poorly constructed barns Excessively warm weather is far more injurious to the dairy cow than cold and there is no practicable means

[3] Woodward, Turner Hale and McNulty U.S.D.A Bulletin 736 (1918)

of making the animal comfortable under such conditions. For this reason hot weather and warm climates are not conducive to a high production of milk. This is especially the case where high temperature is combined with a high humidity of the atmosphere.

PERSISTENCY IN PRODUCTION

A cow that maintains a medium but consistent production over a long period often makes a greater total production for the year than one that is much higher in the beginning but does not hold to this high level long. Persistency in milk production is partly the result of inheritance and is in part the result of feed and management. Frequently a cow that milks well at the start but declines rapidly does so on account of not receiving sufficient feed to supply the nutrients needed. She draws on her body reserve for a while, then when this becomes low, declines rapidly in milk production. The feeder should especially concern himself to feed as liberally as necessary to supply the nutrients needed for the milk produced, in order to hold up the production as long as practicable.

It is very important to understand that when the stimulation to produce milk is lost, it is impossible to restore it. When a cow is allowed to drop in milk production as the result of insufficient feed, it is impossible to bring the milk flow back to the point where it should be by remedying the defect in feeding. For example, a cow calving in May and producing forty-five pounds daily at the maximum in June should produce about forty pounds daily in July and thirty-five in August. If allowed, as the result of poor feed, to drop to twenty pounds in August, it is impossible by correcting the ration in September to bring the yield back to thirty-two, the amount she should be producing at that time. The change to a good ration at this time will result in increasing the milk yield possibly to twenty-five pounds daily, but the effect of the decline in August will be in evidence for the remainder of the lactation period.

The successful herdsman makes sure that the dairy cow is so handled and fed that the decline in milk yield with the advance of lactation is no more than normal. The secret of securing satisfactory production is maintaining persistency.

THE FLY ANNOYANCE

Cattle in the United States are troubled mostly by two varieties of flies, known as the stable fly, *Stomoxus calcitrans,* and the horn fly, *Hæmatobia serrata.* The stable fly resembles the ordinary house fly in appearance, but while the house fly does not bite, the stable fly has mouth parts that enable it to pierce the skin and suck the blood of animals. The eggs are laid usually in manure, horse manure preferably, but also in cow manure and in piles of straw which are fermenting and rotting. The period of development is about fifteen days from egg to adult fly.

The horn fly was introduced into America about 1886. It is considerably smaller than the house fly, and gets its name from its characteristic of gathering about the base of the cow's horns. It is also recognized by its habit of feeding with the wings spread, and usually goes in swarms. Its bite is very irritating and causes a congestion resembling the bite of a mosquito. The eggs are laid in fresh manure, and require about ten days to develop adult flies. These flies remain with the cattle constantly, roosting largely on the horns.

Since flies that annoy cattle are hatched mainly in manure, the first precaution to be observed in reducing the numbers to the minimum *is to avoid an accumulation of manure where it will remain* moist, especially near the barn. Since horse manure seems to be preferred by these pests, special care should be taken not to allow it to remain in heaps near the barn. Where a small amount of manure accumulates, it is sometimes kept in a screened enclosure. When the weather is damp, so that the manure dropped in the field remains moist a sufficient length of time, the flies hatch freely whenever droppings are found.

Fly Repellents. The popular idea of the great injury done by flies results in many proprietary mixtures being put on the market designed for the purpose of keeping off the flies. These compounds are usually composed chiefly of some light petroleum distillates with the addition of pyrethrum flowers. These are applied to the animal with a hand spray pump. Great claims are made by the manufacturers regarding the injury done by flies and the profit resulting from using

these repellents. However, investigations made by at least three experiment stations have failed to show any great advantage from their use.

Since the war several new spray compounds using DDT and chlorinated camphine have proved very effective and have come into general use. They are more commonly used as a fog in the barn to kill flies brought in by the cows.

The Use of Screens. The inexperienced often are surprised that screens are not used more generally on barns. Experience shows that screens on windows of a dairy barn are worse than none unless some means can be devised of getting the animals into the barn free from flies. The trouble is that when the cows enter the barn, multitudes of flies accompany them. When the animals are in the barn, many of the flies leave the animals and go to the windows and are left behind when the cows leave. Screens actually act as fly traps and add to the fly problem in barns.

Screens should be used by all means on the milk room, with double-screen door provided between it and the barn. It will be found advantageous to have the screen open outward in order that the room may be cleared of flies during the day. A fan blowing a current of air over the milk strainer will keep flies away completely.

Electric Fly Screens and Traps. Within the past few years especially, constructed sections of window screens and sections of doors have been charged with electricity. The same principle has been used in especially constructed fly traps. The general use of the new insecticides may make such equipment unnecessary.

DECLINE IN MILK PRODUCTION IN SUMMER

Under conditions typical for the greater part of the United States, the average dairy herd produces milk in abundance in the early part of the summer, but during the latter part of the season the production declines very rapidly.

A compilation from the records of an Iowa creamery illustrates this point. Sixty patrons supplying this creamery sold only 46 pounds of milk on August 1 for each 100 pounds delivered June 1. At the same time, for each 100 pounds produced by an experiment station

herd June 1, 68 pounds were produced August 1 These figures from the farmers' herds represent the typical conditions, and the results from the college herd show that this decline in production as a result of the late-summer condition may be greatly reduced by proper measures

Causes of the Decline in Late Summer. The cause of this rapid decline in milk production as the summer advances is the result of a combination of factors The popular opinion seems to be that the annoyance from flies is the chief cause, but there is evidence that this factor is overestimated The dropping off in milk produced seems

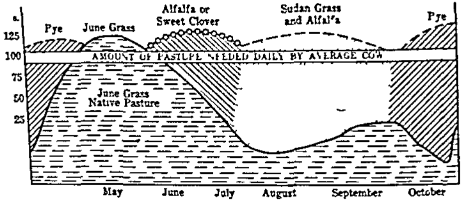

FIG. 67 This figure illustrates the need of supplementary pastures to furnish a uniform supply for satisfactory milk flow

to be fundamentally a question of feed The flies and the hot weather are factors in so far as they both discourage the animals from grazing as they otherwise would Even if pastures are abundant and palatable, the cows dislike moving in the hot sun and often spend most of the day standing in the shade

In many regions a shortage of rainfall in midsummer results in an actual shortage of available feed in the native grass This is well illustrated in Fig 67 Furthermore, the forage which is on hand is less palatable on account of a greater maturity of the plants

That the question is mainly one of feed is further borne out by the experience that when cows are given an abundance of feed so they can get it without effort, there is but little tendency for an ab-

normal decline in milk production to occur. Only too often the condition of the pastures in midsummer offers sufficient reasons for the poor results obtained.

The final result is that the cow, especially if producing a liberal amount of milk, consumes an insufficient supply of nutrients to maintain her production. As a result, she loses flesh on account of taking material from her body for a time to supplement the food received. A dairy cow with a strong stimulation to produce milk will do so for some time even if the feed is insufficient, but soon the production declines, slowly at first, then more rapidly as conditions become more extreme.

Maintaining Summer Milk Flow. As pointed out elsewhere, one of the highly important factors in securing a large milk production for the year is to prevent premature declines, as it is impossible to bring an animal back that has once been allowed to decline on account of poor feed or treatment. For cows that freshen in the spring, especially, it is highly important that the milk production be kept up during midsummer, since if allowed to drop at that time it cannot be brought back to the point where it should be, and the result will continue to the end of the milking period.

The plan to be adopted to maintain the milk flow during this period will depend upon a number of conditions. First of all, if the cows are on pasture they should have opportunity to graze during the hours of early morning and late evening. It will be observed that during hot weather the animals graze but little during the day, preferring to stand in the shade or a pool of water. As a result they come to the barn hungry, and if they are kept overnight in a dry lot, as is often done, but little grazing is done.

The plan has been recommended by some of housing the cows during the day in a darkened barn to avoid annoyance from flies, letting them out at night to graze. The objection to this is the difficulty of keeping the stable dark and at the same time cool and comfortable. Again, the extra expense of labor in cleaning the stable and supplying bedding makes it impracticable in most cases. Also, cows graze but little after actual darkness falls.

Supplementing the Pasture. Keeping in mind the conclusion that

the problem of maintaining milk production in summer is largely that of furnishing a suitable feed supply easily accessible, the question arises as to the best and most economical means of meeting this demand. Some depend upon feeding concentrates for this purpose. There is a growing belief that over wide areas the use of *special cultivated pasture crops* such as Sudan grass, and the use of alfalfa and sweet clover as pasture are the most practical means of supplementing ordinary or native pastures.

The question of grain feeding in summer is considered in detail in connection with the discussion of feeding. It may be stated here that the use of grain is an effective means of maintaining milk production when confronted by the unfavorable conditions of middle and late summer. However, it is an expensive practice to the extent that the grain replaces the grass. Under very poor pasture conditions the roughage consumed by the cows from the pasture may be insufficient even when rather heavy feeding of grain is practiced, and some dry roughage may be necessary.

The use of soiling crops, that is, of crops grown to be cut and fed green, will supply succulent roughage in place of grass. The objections are the labor expense of cutting and hauling heavy green material daily and the difficulty, because of variable weather, of having suitable crops ready at the time needed.

The Summer Silo. The use of silage for winter feeding has become almost universal among dairy farmers in those regions where suitable crops for the silo flourish. In recent years there has been a tendency to lengthen the period of silage feeding and make use of a special silo for summer feeding. A silo for use in hot weather should be smaller in diameter than that required for winter feeding, in order that more may be fed off daily and by this means the danger of spoiling reduced. Silage may be kept without loss from one year to another, and if not needed during the summer months, the silo may be refilled in the fall after taking out the layer of spoiled material which forms on top when the silage is not being fed regularly. Silage is not a complete ration for a dairy cow. It may be used alone to supplement pastures, but if the conditions are such that most of the feed has

to be supplied outside the pasture, then the feeding produced should be practically that of winter. A legume hay should be supplied as additional roughage, and concentrates fed in proportion to the milk production.

USEFUL LIFE SPAN OF DAIRY COWS

The average dairy cow is mature in regard to milk production at about five years of age. Up to this time she has returned but little profit, as it takes from one to three years for her to repay the cost of raising to milking age. It is important, therefore, to know how long she may be expected to stay in profitable production and how to insure and extend this period. Annual depreciation in value of dairy cows is probably the largest item, after feed and labor, in the cost of milk production. Long production life of good dairy cows is essential in any profitable dairy herd.

The average production span of usefulness of dairy cows in American dairy herds is short, four to five years. This is much shorter than in European herds where it will average six to seven years. A survey of 101 commercial dairy herds in Florida[4] maintained largely by purchased replacements was 3.9 years after purchase, while a comparable survey of herds maintained by home-raised replacements was a productive life span of 4.7 years after coming into milk.

The causes of removal of dairy cows from the herd are many. The more important may be listed from the Florida report: Mastitis and udder trouble 21.3 per cent; low production 18.8 per cent; reproductive troubles 12.7 per cent; death from disease and unknown causes 14.2 per cent; accidents and poisoning accounted for 12.6 per cent. The last item is a large one and largely unnecessary, being caused by injuries from foreign bodies such as wire and nails in feed, poisoning from toxic plants and paint, fertilizers, sprays, etc.

The shortening of the productive life span of a dairy cow for any of the above or other reasons is important in the profits and successful handling of a dairy herd. Every effort should be made to reduce them whenever possible. In order to have a basis for such a program

[4] Becker, Florida Experiment Station Bulletin 540 (1954).

of management, careful and systematic records of milk production and of breeding should be kept and carefully analyzed The inferior producers and those which are diseased should be sold at once regardless of age The high-producing cows should be kept disease-free and in breeding condition as long as possible Many cows are good producers and breeders at twelve or more years of age

CHAPTER XXII

Care and Management

(*continued*)

GIVING THE COW A REST

The production of a liberal amount of milk is a severe tax upon a cow. Even the very moderate amount of 6,000 pounds of milk in a year means the manufacture of 750 pounds of dry matter, or more than the total dry material in the carcass of a steer weighing 1,250 pounds. Experience has shown that a cow will produce more milk in a year if allowed to have a dry period of six weeks or two months than she will if milked continuously. For this reason the universal practice among experienced herdsmen is to allow this interval for restoring the physical condition preparatory to the labors of the following year. Under ordinary conditions the cow should be dry six weeks at least, and if she is in poor flesh, two months is better.

As a result of recent investigations in nutrition it seems probable that the special value of the dry period is to allow the animal to recuperate the mineral supply of her body, especially the calcium and phosphorus which are drawn upon during heavy milk production. A cow that is not given a rest before calving will begin her milk production at a much lower nutritional level than will be the case when she has had opportunity to recuperate.

The belief is often held that milking a cow up to the time her calf is born will result in the calf being weak and small from lack of proper nourishment. This assumption is not borne out by experi-

mental observations The mother and not the calf is the one to suffer The nourishment of the fetus comes from the blood of the mother, and this fluid always remains practically the same in composition except under conditions of prolonged deficiency

Drying Off the Cow With a large proportion of the ordinary cows used for dairy purposes there is more difficulty in keeping them milking as long as desired than in getting them to take a rest However, many of the highly developed dairy cows will milk continuously unless dried up intentionally by the owner With such animals, difficulty is sometimes experienced in getting the secretion of milk stopped Occasionally the excuse that she could not be dried off is given for not giving a cow a rest before freshening

Milk secretion is caused by hormones produced by certain glands in the body, which are stimulated in part by the act of milking In the early part of lactation the stimulation due to the milking act is overshadowed by the natural functioning of the glands producing lactogenic hormones At this time it is difficult to dry up a cow After several months the stimulating effect of the milking procedure becomes of greater importance Later in lactation it is apparently the dominant factor When this point is reached, drying off the cow becomes possible Advantage is also taken of the fact that the pressure developed within the udder between milkings will itself inhibit the secretory mechanism [1]

The common method of drying a cow is to lengthen the interval between milkings by omitting one milking each day After a few days the milk is drawn only once in two days, until secretion is completely stopped This may require two weeks or more

There is far less danger of injuring the cow's udder in drying her up than is generally believed After the cow has passed the eighth or ninth month in milk, milk production depends largely upon the stimulation from the act of milking If a cow is free from mastitis and is producing as little as ten pounds per day, milking can be stopped at any time and no harm will result The udder should not be milked out at all It will fill up for a few days and then the milk contained

[1] Petersen and Rigor Proceedings Society Experimental Biology and Medicine 30 254–256 (1932) Wayne Eckles,* and Petersen *Journal Dairy Science* 16 67 78 (1933) Turner Missouri Agricultural Experiment Station *Bulletin 345* (1935)

is gradually reabsorbed and no harm will result in any case. If a cow is producing more than this amount of milk, it is advisable to reduce her feed. The grain ration should be entirely removed and a poor quality of roughage low in protein supplied for a few days. With this treatment the production will decline rapidly, and when it reaches a level of eight to ten pounds daily, the milking may be discontinued entirely.

A new practice coming into use in large well-managed herds is to move the cow from the milking line to another barn. This changes her habit and environment. She is then fed on timothy hay and little or no grain. The udder is well milked out and left alone. In case the cow has a history of mastitis in one or more quarters, the udder and teats should be carefully washed with a disinfectant solution, after which penicillin is injected in each teat or quarter. Again the teats are well washed and disinfected and coated on the ends with collodion. It is seldom necessary to milk the udder because of milk accumulation, and mastitis seems to be reduced in the next lactation. This *should be done only by a skilled veterinarian.*

If, through some oversight or otherwise, a cow is continued in milk until within about three weeks of the date she is due to freshen, the milk production begins to increase gradually and it is more difficult to dry her up than if it is begun about two months before the date for freshening. This is apparently due to a renewal of the natural functioning of the glands producing the lactogenic hormones. It is hardly advisable to attempt to dry up a cow within ten days or two weeks of freshening—she shows the usual tendency to increase in milk production under these conditions.

Management of the Dry Cow. The physical condition of the cow at time of freshening has a distinct relation to the milk production for the entire lactation period. Experience shows that if a cow freshens in a poor physical condition as the result of not having been dry long enough, or because of poor rations during a period preceding, she starts considerably below her normal level of milk production and no amount of care in feeding and management later will bring her up to the level she would have reached had she been in proper condition.

For example, a certain cow may have the capacity to produce forty pounds of milk daily when fresh, provided she is in good condition If she is allowed to freshen in a poor condition, she may never exceed thirty pounds daily and will decline at about the normal rate, resulting in a lower daily production, not only at first but even after six months in milk Fig 68, based upon actual results, shows what may be expected In this case, when the cow was in good condition, she produced 36 pounds daily at her best and a total of 6,544 pounds

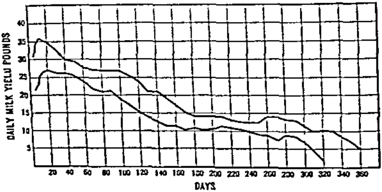

FIG. 68 Relation of physical condition of the cow at parturition to milk production The upper line on the chart represents the milk production of a certain cow during a lactation period When started she was in good physical condition She produced 36 pounds daily at her best and 6 544 pounds for the year Another year she freshened in poor condition and produced milk as shown by the lower curve Her best this year was 27 pounds daily and 4 468 for the year Note that at no time following the poor start did she reach the production of the other year

for the year At another time, as the result of freshening in poor condition, she followed the lower curve, producing a maximum of 27 pounds a day and a total of 4,468 pounds for the year

Additional reasons for having the cow in good condition are that less trouble will be experienced in parturition and from the retention of the afterbirth Those who recognize the practical importance of feeding the cow will, during the period preceding calving, sometimes make the error of assuming that the reason for liberal feeding at this time is the necessity of supplying nutrients for the development of the fetus The tax upon the mother to develop the fetus is really very

small—too small, in fact, to be measured in feed nutrients requ A calf weighing 70 pounds at birth may contain only 17 poun dry matter. A cow in three days' average production produces as much dry matter as is found in such a calf at birth.

Another assumption sometimes made is that if the cow is not fed well preceding the calf's birth the calf will be undersized. Experimental work has shown that the feed received by the mother has no effect whatever upon the size of the calf unless conditions of feeding are far more abnormal than are found under practical conditions. It should be recognized that poor feed and management, resulting in a low physical condition at time of freshening, are not measured by the effect upon the calf but upon the cow and her level of milk production during the lactation period which follows.

Rations for the Dry Cow. The feeding of the cow while dry will depend largely upon her condition of flesh when she goes dry. If she is in good order—that is, somewhat more than moderate in flesh—little more than a good maintenance ration will be needed while dry. There is no more suitable ration for such a cow than good succulent pasture or good legume hay and corn silage. If she is thin, the ration should be sufficient to insure that she will be in proper condition at calving time. There is no special grain mixture to be recommended for the dry cow. The same ration as fed the cows in milk is satisfactory. A suitable combination would be equal parts of corn meal, oats, bran, and oil meal.

About two weeks before calving, her grain ration, if heavy at the time, should be reduced to from two to four pounds daily and should be of such character as to maintain a laxative condition. Many skilled herdsmen give a dose of Epsom salt at the first signs of calving.

The dry cow should have some exercise, and nothing is better for this purpose than freedom in the pasture. She should never be hurried or be driven by dogs or driven through narrow gates.

When cows are placed on official test, the feeding during the dry period should be especially liberal, as it has been found that having the cow in a good state of flesh at time of freshening is one of the first essentials in getting a good milk and fat record.

CALVING AND ITS PROBLEMS

Milking Before Calving With some very heavy milkers the udder becomes so distended before parturition that the breeder, especially if inexperienced is often afraid that injury to the cow will result if she is milked Milking before the birth of a calf should be practiced with caution It is evident than an animal may suffer under these conditions from the great distention of the udder, but no fear need be felt that injury to the udder will result if she is not milked Milking previous to the birth of the calf tends to delay the onset of parturition on account of the close relation between the nerves of the udder and those of the reproductive organs For high producing cows the practice of milking before calving is becoming more widely accepted

Care of the Cow at Calving Time If the cow has been dry for a time and has been properly fed so that she is in good condition at calving time, complications will not be frequent If the cow is on pasture and the weather is good, she should be allowed to remain there, but looked after at least twice a day If not on pasture the cow should be turned loose in a box stall of sufficient size several days before she is expected to calve The stall should be thoroughly cleaned and disinfected before being occupied As the time of parturition approaches, the udder becomes distended and hard, and filled with colostrum milk When the tendons and muscles relax, leaving a hollow appearance on either side of the tail head, parturition may be expected within 24 hours, or three or four days at the longest

The cow should be left strictly alone at time of calving, unless some assistance is evidently necessary As a rule the calf will be born within half an hour If the calf is not expelled after an hour or two, an examination should be made The normal position of the calf at the time of delivery is front feet first with the front of the hoofs and knees upward while the nose lies between the knees If the condition of the calf is normal the cow may be assisted by pulling on a rope attached to the fore feet of the calf This must be done carefully and only when the cow strains

If the position of the calf is abnormal, that is, if it is coming hind feet first or the head doubled back, or if any other abnormal condition is presented, the owner should waste no time in securing a competent veterinarian.

Retention of the Afterbirth. After the birth of the calf, special attention should be given the calving cow. The cow is especially subject to the retention of the afterbirth, and special attention must be given that it comes away as soon as possible. When the cow is in good condition, the afterbirth is usually expelled in the natural way within a few hours after the calf is born. Cows far along in years, in low condition of health or vitality, or following abortion are especially subject to the trouble of retention of afterbirth.

When a retained afterbirth does occur, the cow should be isolated from the rest of the herd and treated as if the cause was infectious. This is a safety precaution against the possible spread of infectious disease such as contagious abortion to the rest of the herd. The sick cow should be placed in a clean, warm, comfortable isolation pen or box stall. This stall should be well bedded and the cow kept quiet and warm. If in winter or cold weather the cow should also be well blanketed. Water given the cow should be warm and fresh. A well salted warm bran mash may also be given, and all roughage should be only the best alfalfa or mixed hay.

If after a few hours the afterbirth has not come away, a skilled and competent veterinarian should be called. There may be many different things which may cause this abnormal condition, and proper treatment cannot be started until a careful examination has been made by one experienced and qualified to handle such cases.

Where a skilled veterinarian may not be available, the person in charge should proceed to take such practical measures as will assist nature in the removal of the afterbirth.

The herdsman will see that the cow is kept isolated, quiet, warm, and comfortable and fed only on the best palatable and laxative feeds.

He will usually introduce deep in the afterbirth cavity two or three standard uterine capsules. These may be purchased at most

drugstores They help to keep down putrefaction of the retained afterbirth membranes and may also assist in loosening the afterbirth attachments

The exterior vaginal parts should also be kept clean by frequent washing with a good warm antiseptic solution

It may be several days before complete separation and passage of the afterbirth will take place

Care of Cow After Calving It should be borne in mind that the vitality of the cow is low following parturition, and she should be treated accordingly She should be protected from cold drafts, and in case of severe cold weather it is well to cover her with a light blanket for a day or two *She should be given warmed water for two* or three days The ration for the first few days should be light in character and not very abundant A bran mash made by moistening bran with warm water is well adapted for the grain portion With this can be given such amount of hay as will be readily eaten If the udder is swollen and hard, the grain ration should be increased very slowly until this condition disappears, when more feed can be added As a rule it takes two weeks at least, and with a heavy milker still longer, to get her on full feed The most successful herdsmen watch this point with great care No alarm need be felt if the udder remains inflamed and somewhat hard for a number of days, provided milk can be drawn freely from each quarter The cow should be milked at least three times daily, or oftener, until the inflammation leaves the udder

Guarding Against Milk Fever Milk fever occurs most often with high producing cows It seldom occurs following the first calf of a heifer It affects mature cows, and especially the heaviest milkers In recent years the practice has become general especially with high-producing cows liable to have milk fever, of milking out a little milk at a time several times during the day until the danger of this trouble is past Only sufficient milk is drawn to relieve the extreme pressure as it is believed advantageous to leave enough milk in the udder to cause considerable pressure during the dangerous period When the age and condition of the cow suggest danger from this source, a careful watch should be kept on the animal especially

during the first forty-eight hours, and to a less degree for a few days more.

The first indication of milk fever is uneasiness, a dull staring eye, and an unsteady gait. Within an hour or two the cow is down and soon becomes partially or totally unconscious and assumes a characteristic position, lying with her nose pointed back toward her flank. Often the cow will be in the unconscious state when first discovered. Anyone responsible for cows liable to have milk fever either should have a suitable outfit at hand at all times for treating it, with the necessary knowledge of how to use the apparatus, or should at once call for the services of a competent veterinarian. Further details concerning the treatment of milk fever are given in the discussion of disease.

Care of Newborn Calf. After the calf is born the mother should be allowed to lick it dry. If the weather is very cold or the mother does not seem disposed to lick the calf vigorously, it is advisable for the herdsman to assist in cleaning and drying the calf, using a piece of burlap or other coarse cloth for the purpose. The entire navel cord should be disinfected by dipping it into a cup containing tincture of iodine or by painting the iodine over the surface. This should be done immediately after the calf is dropped, otherwise infection may be picked up from the floor or bedding.

If the calf is strong and vigorous it will be on its feet and nursing within a few hours. In case it is weak and does not take milk after three or four hours, it is well to give some assistance by holding it up to its mother. The calf should have the first or colostrum milk, but if this is impossible on account of sickness of the dam, and milk is used from another cow, about an ounce of castor oil may be given with advantage to assist in cleaning out the digestive tract.

While the calf is still with its dam it should be marked according to the system in use in the herd.

It is best to take the calf from its mother at the end of twenty-four hours and place it in an individual stall. The care and feeding of the newborn calf is explained under the chapters on "Calf Raising."

Developing Long Milking Period. Persistency in milking is mostly a breed and individual character, but it is believed by some

that it is possible to influence the length of time a cow will give milk each period during her life by the length of the first milking period This possibility has never been studied experimentally, and there is some reason for questioning if the length of the lactation period is so easily determined A more reasonable view would be that persistency in milk secretion is an inherited characteristic Where a cow with a tendency for a short lactation period was thought to have developed this characteristic as the result of having been dried up too soon when a heifer, it is possible that the short milking as a heifer was the result of inheritance and the question of forming a habit did not enter into it at all However, in view of the common belief and the lack of any experimental evidence, it is well to milk a heifer in her first lactation period as long as she should be milked when mature, even if the milk secured does not justify the time

WATERING

Water Requirements Cows that are producing milk require a much larger quantity of water than is necessary for growing animals or for those that are merely being maintained, as in the case of wintering breeding stock of the beef breeds This is caused by the necessity of providing water to be used in the milk itself and for the digestion and assimilation of a large quantity of feed, much of which is roughage

The author found that a Jersey cow producing 27 pounds of milk daily consumed 77 pounds of water Another of the same breed producing 13 pounds of milk used 40 pounds of water A Holstein cow producing an average of 110 pounds of milk daily consumed from 215 to 350 pounds of water daily during the seven days covered by the data These figures bear out the results obtained by others and indicate that the cow uses water at the rate of about three pounds to each pound of milk produced

The character of the ration has some effect, as might be expected, upon the water required When green feed or silage is fed the water consumption is not as great as when the ration is confined to dry hay and grains The marked difference in the demand for water by the cow in milk and the animal on maintenance is shown by additional

figures taken of the water consumption by the same Jersey cows when dry. Under this condition one used 15 pounds of water daily compared to 77 when producing milk, and the other 9 pounds as against 40 when producing 13 pounds of milk daily. As shown in these figures, the large water requirement by the cow in milk suggests, as has been found by practical experience, that it is exceedingly important to supply an abundance of good water to cows producing milk. It is evidently much more important that an abundance of water close at hand, and not too cold, be supplied to heavy-milking cows than is the case when the animals are on maintenance only. Cows that are not producing milk do not need to be watered more than once a day in the wintertime, and at this season they do not seem to care for it oftener than this. In the summer the consumption of water by cattle on maintenance is greater on account of the greater evaporation from the skin; and while cattle thrive when watered once per day, they relish it oftener and will do better if supplied twice per day or oftener. Cows on heavy feed and producing large quantities of milk should always have access to good water at least twice per day at all seasons. For the best results with dairy cows, water of good quality should be supplied close at hand. If they are required to walk a long distance in cold weather, they will not drink a sufficient amount on account of the discomforts of exposure, to supply the demands of the body and will give a smaller amount of milk than they otherwise would, because of not having consumed a sufficient quantity of water. The cow may suffer for lack of suitable water just as easily as for lack of feed.

Source of Water. The best source of supply for drinking purposes for dairy cattle is deep well water supplied through individual drinking cups and available at all times. Next to this are running streams or springs. Ponds may be used if they are so placed that there is no drainage from barnyards or about dwellings, and if the animals are not allowed to wade into the water. Ponds which are filled with contaminated drainage water or in which stock of any kind are allowed to wade and to pollute with their own excrement are entirely unsuitable as sources of water supply. Not only should the use of such water be avoided for sanitary reasons, but the amount

of water consumed under these conditions is liable to be below the real requirement of the body

Watering Cows in the Barn One of the most useful features of modern barn construction and equipment is the use of watering cups in the barn The outstanding advantage is the possibility it affords for the cow, requiring as she does such large quantities of water, to drink a small amount at a time and at frequent intervals There is no question that when the plan is followed of watering at an outside tank once or twice a day, the heavy producing cows, during the winter especially, often fail to consume as much water as they need for best results

The economy of labor is also an important factor to be considered, because provision for watering inside avoids the necessity of turning the cows loose for the purpose of watering The first plan introduced for watering in the barn was that of building the manger in the form of a continuous trough with a drain to carry away the surplus When the cows were to be watered the manger was swept clean of feed and filled with water This plan is no longer advocated because of the spread of tuberculosis and other mouth-borne diseases In all modern well-equipped barns individual drinking cups are installed These are constructed so that the animal opens the valve by pressing with the nose or by raising the cover, and water continues to run so long as she drinks Cows quickly learn to use them When the animal drinks small quantities at a time, the necessity for warming the water is removed

Perhaps no part of the modern barn equipment yields more return on its cost price than well-constructed individual drinking cups When properly installed, about the only difficulty experienced is from freezing if the barn is not so constructed as to keep the temperature above the freezing point

Warming Water for Dairy Cattle In climates where the temperature remains below freezing for long periods it is profitable to use some means of warming the water when the animals drink from a tank outdoors In addition to the minor advantage of having the tank free from ice, the chief value of warming the water in the outside tank is to insure that the cows will drink a sufficient amount A

heavy-producing cow depending on size requires from 70 to 350 pounds of water daily and will not consume a sufficient amount if the water is near the freezing point.

Assuming that a cow producing 40 pounds daily was watered twice a day, each time she would find it necessary to take about 60 pounds of ice water into her stomach. The effect upon digestion and milk secretion of such a volume of cold water is found to be detrimental.

Formerly the economy of saving feed by warming water was emphasized. It is undoubtedly cheaper to warm water with a tank heater constructed for the purpose by burning coal or wood than it is to supply the same amount of heat by allowing the animal to burn up high-priced feed in its body. However, the present view is that a heavily fed cow has some surplus heat that may be used for warming water if necessary, and therefore the saving in feed by warming the water may be easily overestimated. However, the first reasons given are alone sufficient to justify making suitable provision so that no dairy cow will be required to endure the exposure to storm and cold and to drink ice water. If she receives this treatment, her owner will pay the penalty in a production far below what it might be.

SALT REQUIREMENTS

All animals that consume large quantities of vegetable food require salt. Carnivorous animals do not have this craving, neither do human beings who live mostly upon meat. According to the widely accepted theory of Bunge, the cause of this salt requirement by herbivorous animals is the large quantities of potassium which they consume with the plant food. Because of the alleged antagonistic relation between sodium and potassium in the body, an excess of potassium is regarded as causing sodium to be lost in the urine. This leaves the body short of sodium and causes the craving for sodium chloride. This theory has not been substantiated by ample experimental investigations, however.

Babcock[2] reported extensive investigations on this subject. He kept cows in milk without salt for periods up to one year. The composition

[2] Wisconsin Agricultural Experiment Station 22nd Annual Report, pp 129–156 (1905).

The secretion of milk is involuntary, but is greatly influenced by the "let down" hormone, oxytocin, first described by Dr W E Peterson This hormone is secreted by the pituitary gland in the brain and its secretion is brought about normally by the calf's sucking or by the washing and manipulation of the udder by the milker

The secretion of milk may be affected indirectly by excitement of any kind Even the presence of a stranger or a dog at milking time is sufficient to affect the milk yield of many cows The changing of milkers results in some loss for a few milkings, unless the new milker is unusually efficient

FIG 69 Having the udder clean before milking is highly essential

A cow should be milked quietly and quickly A cow is largely a creature of habit If usually fed at the time of her milking, she cannot be milked satisfactorily until she has her feed. Special care should be taken to secure all the strippings However, Woodward, Hotis, and Graves[1] conclude that while not much milk should be left in the udder, too much time should not be spent trying to get the "last drop" of milk, otherwise the cost of stripping may exceed the value of the "strippings" The first milk drawn may contain as little as 1 per cent of fat, while the last drawn runs from 6 to 10 per cent fat In milking, the whole hand should be used, closing first that part next to the udder, then the milk is forced past the sphincter muscle by closing the remainder of the hand The milking should not be done by using the thumb and forefinger alone, neither should the thumb be enclosed within the palm, as is sometimes done The cow's teats should always be dry when milking Wetting the teats not only is a filthy practice, but it also allows the teats to chap and become sore in cold weather If there is difficulty in milking dry, a

[1] U S D.A Technical Bulletin 522 (1936)

small amount of vaseline may be rubbed on the hands. This serves the same purpose as wetting the teats, and is beneficial rather than harmful, both in a sanitary way and as it affects the cow's teats.

Milking More Than Twice Daily. Under ordinary conditions the usual practice of milking twice daily is practical and sufficient. The intervals between should be as nearly equal as possible. Occasionally there are conditions which justify milking three times daily. Heavy-producing cows will increase their yield by an additional milking while small or medium milkers show no appreciable increase. Few cows will produce over 50 or 60 pounds, at the most, with twice-a-day milking. For the Channel Island breeds 35 to 45 pounds mark the same limits. With high-producing cows a third milking makes it possible not only to make use of the full capacity of the animal but also to hold the production to a high level for a longer period.

The increased production obtained by additional milkings apparently is explained chiefly as follows. The secretion of milk is a continuous process and is not limited to the milking act. The most *rapid rate of secretion occurs during the period immediately following* the complete release of the udder pressure following a normal milking. If the maximum pressure of a full udder is maintained too long, the next cycle of normal secretion will be impaired and even inhibited. By shortening the intervals between milkings, advantage is taken of these normal relationships to increase the milk yield. Cows having marked internal stimuli naturally respond to a greater extent to this procedure than cows having small stimuli. The matter is explained in greater detail by Turner[2] and by Garrison and Turner.[3]

Riford[4] changed 50 cows averaging 45 pounds of milk daily from two- to three-time milkings daily. The average increase was four pounds of milk daily. It was noticed that the fresh cows responded best. He later compared the milk produced by a group of 25 cows on three milkings daily with the best production in previous lactations with two milkings daily. The increase due to the third milking varied from 9.1 to 13.2 pounds daily. He concluded that the third milking adds about 10 per cent to the production of cows ranging between 40

[2] Missouri Agricultural Experiment Station Bulletin 346 (1935).
[3] Missouri Agricultural Experiment Station Research Bulletin 234 (1936).
[4] *Hoard's Dairyman*, 63:661 (1922).

and the quantity of the milk produced was not affected by withholding salt for short periods Cows without salt showed a strong craving for it after two or three weeks, then quieted down and gradually changed into a condition of low vitality, rough coat, and emaciated condition, which resulted finally in complete breakdown In most cases the cows recovered their normal condition when given an abundance of salt He found that cows consume about one ounce per day when allowed to eat as their appetite demands He concluded that three quarters of an ounce per day per 1,000 pounds live weight is sufficient, with six-tenths ounce in addition for each 20 pounds of milk produced Recent studies at Cornell[3] show that cows on pasture with free access to rock salt consumed only 1 5 ounces per day, while cows allowed free access to loose salt consumed about 2 8 ounces per day From these studies it may be assumed that cows need from one to three ounces per day of salt Babcock's investigations indicated that chlorine is the essential element supplied by salt, because the sodium chloride starvation could be relieved by potassium chloride

Salt may be supplied by mixing the proper amounts regularly with the feed, or it may be placed where the animal can consume such amounts as the appetite demands Heavy-producing cows should not be required to secure their total salt requirements from rock salt placed in the yard or pasture The common plan of salting the cattle only at intervals of one or two weeks is not to be recommended

[3] Cornell Farm Research Bulletin (1951)

CHAPTER XXIII

Milking Factors Influencing the Quantity and Quality of Milk

MILKING

Milking the Heifer. If the heifer is properly handled before she has her first calf, there is little difficulty in teaching her to be milked. If the heifer has been tied while being fed as a calf, there will be no further trouble about tying her at any time. The heifer should be accustomed to the stable where she is to be tied for some time before she calves. For a month or more before she freshens it is best to tie her in the stall she is to occupy when in milk, and to make a point of handling her daily. A careful attendant should have the milking of her at first, and must go about it carefully and without exciting her. The attendants who care for cows should always move about among them gently and not startle them by sudden movements or loud talking.

Methods of Milking. Milking is generally considered such a simple operation that any common laborer is supposed to be able to milk. However, there is an immense difference in milkers, and one of the most difficult parts of carrying on dairy farming is that of securing competent men to do this work. One milker may be able to get 20 per cent more milk than another, one may dry the cow within a few months, while another may keep her in milk the entire year. The milker should not be allowed to excite or worry the cows by loud talking or cruelty or abuse of any kind.

and 50 pounds daily, while for those near 60 pounds the increase is about 20 per cent

Seventy or 80 pounds of milk daily for a Holstein or 50 for a Jersey is near the upper limit for three milkings daily If the animal has a capacity above 50 pounds four milkings may be necessary to secure the maximum yield, although the practice of four milkings is not common

When a number of heavy milking cows are in a herd and other duties are not too pressing, a third milking may pay liberally for the time required When purebred cows are on official test and the object is to obtain the maximum amount of milk regardless of economy of labor, three times-a-day milking should be practiced for the greater part of the lactation period, and where the production is very high, four milkings are the usual practice The intervals between the milkings should be as nearly equal as possible, but if this is not practicable, milkings should be done regularly at the same hours When the practice of three milkings is followed, the highest fat test is usually found at the milking coming nearest midday and the lowest in the early morning milking The early morning milking as a rule gives the largest quantity of milk and the late evening milking the lowest

MILKING DISORDERS

Hard Milking Cows Some cows cause considerable annoyance to the milker because they milk unusually hard This difficulty is caused by a strong sphincter muscle, which closes the teat opening tighter than it should Allowing the teats to become dry and harsh also tends to produce this condition The use of vaseline or oil on the teats and milking by a milker with strong hands may partially remedy the condition Cows with scar tissue in the teat may cause hard milking also It is also possible to use teat plugs made of rubber or lead to expand the openings They may cause more trouble than help unless carefully and wisely used When these are used they must be first thoroughly sterilized and the end of the teat well cleaned and sterilized then the plugs may be inserted into the teats after milking and allowed to remain from one milking to another if the cow is con-

fined to a stall. This is continued until the muscles are somewhat relaxed. In some cases this treatment is not sufficient to cause a permanent enlargement of the opening. Therefore, in really hard milkers an operation can be performed to enlarge the teat opening, making it easier to get the milk. In other cases the difficulty in milking is caused by a hard lump in the base of the teat, which seems to drop down into the opening when drawing the milk. The only means of remedying this condition is by a surgical operation. A veterinarian who has had experience in dealing with such cases can often remedy the trouble.

Use of the milking tube. One of the instruments often used by the competent and experienced herdsmen is the milking tube. Everyone having the responsibility of a herd should have a set containing at least three milking tubes of different sizes. It should be understood, however, that if these are used carelessly, serious trouble and udder infection may result. The responsible manager of the herd should see that all instruments and medicines are kept under lock and key and used only under his immediate direction.

In case of injury to a cow's teat, such as by wire cuts, or by having been stepped upon, milking not only is painful for the cow, but prevents the proper healing of the injury. Under such conditions the milk tube should be used until the injury is healed. Providing suitable milk tubes with careful provision for their proper use will remove the temptation for milkers to resort to the use of quills or even straws as is sometimes done, often to the permanent injury of the mind.

Sterilizing instruments. Before a milk tube, a teat plug, or any instrument is inserted into the opening of a cow's teat, the end of the teat must be thoroughly disinfected. If this is not done, germs may gain access to the udder which may cause infection that will ruin the animal. Instruments should also first be thoroughly cleaned in warm water, and preferably boiled. Before being inserted into the teat, they should be placed in a five per cent solution of carbolic acid, or in a rather strong solution of creolin, and should be inserted while wet with this solution and without being touched with the hand on the portion that enters the duct. Milk produced through such tubes must be discarded because of taints from such disinfectants.

Cows with Leaking Teats. Some cows lose a portion of their

milk by leakage from the udder between milkings This is caused by a weak contraction of the sphincter muscle No practical remedy has been devised for this trouble Milking such cows three or more times per day when recently fresh is often practical Under conditions that warrant the small amount of trouble involved, the teat openings may be closed with collodion after each milking

Bloody Milk. Blood in milk is more common than is generally understood. *It often may be noticed in separator slime when its presence is not suspected in the milk.* It is not an indication of disease or

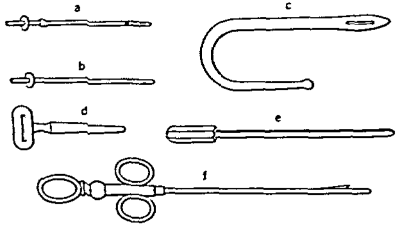

FIG. 70 Instruments for treatment of udder troubles. *a*, *b* milk tubes; *c*, lead teat plug *d*, teat expander *e* teat opener *f* teat litter or bistoury

any unhealthy condition in the cow It is caused by the rupture of a small blood vessel that allows blood to escape into the milk cistern or the milk ducts In some instances certain cows have it at intervals for a number of months, but more often it appears but once or twice It cannot be prevented or stopped, and the only thing to do is to reject the milk affected

Chapped Teats. Sore teats may be caused by cold weather, milking with wet hands, or other causes of local irritation When so affected the cow does not stand quietly for milking, on account of the pain The trouble may be easily remedied The application of vaseline a few times on the first appearance of the trouble will usually check and cure it If chapping be severe, the teats should be thoroughly washed and softened with warm water, after which

zinc oxide ointment may be applied. An application of olive oil is also often recommended.

Warts on the Teats. Warts on the teats are often troublesome. They often disappear or are greatly benefited by applying vaseline, castor oil, or olive oil. If large, they may be cut off with a pair of sharp scissors and the spot touched with a stick of caustic potash.

Kicking Cows. Cows are given to few vices, and those are mainly due to faulty management. The most common vice is that of kicking when being milked. The cows often kick at first, either from pain or fear, and if not handled properly, this may grow into a habit. Under no circumstances should an attendant strike a cow that kicks. It does no good, but always makes them worse. Gentle measures, however, will not work with all cows, and some old cows that have been taught by mismanagement to kick cannot be cured by the best of care. Such animals should always be tied during milking. This is best done by taking a rather heavy strap with a strong loop. The strap is put around one leg above the hock, and the end drawn through the loop. The strap is then put around the other leg and buckled, so the two legs are held close together. The cow may struggle a little at first, but soon learns to stand quietly as long as the strap is in place.

Self-Sucking Cows. This vice is not very common, but it is annoying when begun, and difficult to stop. If an ordinary cow contracts the habit, the best advice is to sell her at once. The most effective method of treatment seems to be to put a bull ring in the cow's nose and hang a second ring or short chain from the first. This method was suggested by the Wisconsin Experiment Station and while unsightly has come into general use by dairymen.

THE MILKING MACHINE

A satisfactory mechanical milker has long been one of the greatest aids of the dairy farmer. The wide opportunity offered for a successful device of this kind early attracted the attention of inventors. A German writer states that 29 different milking machines were known to him between the years 1877 and 1898. The reports of the Commissioner of Patents show that 127 patents on milking machines or

parts were taken out in the United States alone between 1872 and 1905 [5] The successful milker of today is the result of a long period of development, as indicated by the figures given The first really practical mechanical milkers appeared on the market between 1900 and 1910 Modifications and improvements were made constantly until the development seems to have now reached a point of very satisfactory service

The use of milking machines increased rather slowly, but in recent years they have become almost a necessity in herds of any size They are great labor savers Some farmers still find dissatisfaction with them, while other dairymen use them year after year and could not or would not do without them This suggests that success in using a machine of this kind depends largely upon the operator They are no better than the man who handles them

Efficiency of Milking Machines Tests of the efficiency of machines of different types, the relation to the milk yield, and to the sanitary condition of the milk have been made by several experiment stations and the United States Department of Agriculture From these reports it is possible to arrive at a reasonably safe conclusion regarding the general working of these machines in practice

It has been thoroughly demonstrated that milking machines will milk cows and that a skilled operator will do as efficient work as the average hand milker It is still questionable, however, if the milking machine is equal to a skillful experienced hand milker in the amount of milk secured During the early part of the lactation period the cow apparently milks better by machine as compared with hand milking than is the case later in the milking period Most users have found it more difficult to hold up the yield of milk during the last part of the milking period when the machine is used After a cow has been in milk for some months, the stimulation to produce milk is due partly to the act of milking itself Hand milking undoubtedly results in more stimulation of this kind than does machine milking unless machine milking is followed by careful stripping

The cow is not injured in the least and usually very quickly becomes accustomed to machine milking It must be remembered that

[5] Lane U S D A Bureau of Animal Industry Bulletin 42 (1907)

each milking machine should be operated as directed by the manufacturer, especially as to vacuum pressure for the particular machine.

Disadvantages of Milking Machines. Probably the greatest real criticism of the milking machine is the ease with which it spreads infectious udder troubles. This has become so great in some herds that machine milking has been discontinued. Care must be taken to milk any cow last which shows any suspicion of inflammation of the udder, or better still, not to use the machine at all in such cases. A careful sterilization of the teat cups is always advisable, but especially so when there is any evidence of udder trouble.

Since the chief source of dirt in milk is the body of the cow from which it drops during milking, it would appear that the use of the milking machine by excluding this dirt would be an important factor in improving the sanitary condition of milk. However, surveys show that machine-drawn milk usually is inferior rather than superior to hand-drawn in bacterial content. This is the result of careless cleaning of the outfit. If the machine is properly cleaned and used, the sanitary condition of the milk is improved over hand milking; however, if not well cleaned, the milk is in decidedly worse condition.

A farmer considering the purchase of a milking machine will do well to visit farms where different makes are in use and observe their operation. It is also well to select a machine that has been on the market long enough to make certain that the defects have been discovered and corrected. A well-known company is also likely to remain in business, making it possible always to secure replacement parts. The portable unit is a recent development with many advantages, and the direct flow glass line installations are meeting with much favor, especially in new pen-type barns and milking units.

FACTORS INFLUENCING THE QUANTITY AND QUALITY OF MILK

The Breed. It is a well-known fact that the breed of the animal bears a distinct relation to the quantity of milk produced and especially to the fat content. Within a breed the variation in milk yield is far greater than that of the fat percentage. For this reason many individuals within a breed do not show the typical milk yield

of the breed they represent. For example, while the Holstein breed has the highest average milk yield, the lower-producing animals within the breed are decidedly below the higher-producing or even the average, animals of breeds that rank considerably lower in average production. Milk produced by individuals within a breed varies much less in composition than yield, and is generally fairly typical of the breed.

Table 48 gives the average percentage of fat by breeds as shown by Herd Improvement Register records and the large number of records published by experiment stations.

Table 48 *Relation to Percentage of Fat and Total Solids*
(From Herd Improvement Registry and Experiment Station Records)

BREED	AVERAGE FAT PERCENTAGE H.I.R.	EXPERIMENT STATION RECORDS	
		PERCENTAGE TOTAL SOLIDS	PERCENTAGE FAT
Holstein	3.53	12.29	3.45
Guernsey	4.8	14.70	4.98
Jersey	5.32	14.90	5.14
Ayrshire	4.08	12.98	3.85
Brown Swiss	4.01		—
Shorthorn	3.94*	12.85	3.80
Red Polled	4.32*		4.03

* Advanced Registry

Size within the Breed In general, those keeping dairy cows primarily for the production of dairy products for sale prefer a cow medium to large for the breed. The U.S. Department of Agriculture[6] studies show that within the breed the large cow pays. Most breeders of purebred cattle have the same view.

The cows that have made the largest milk and fat records have been without exception large animals for their breed. Woll has also shown that the highest production is found with cows that are large for the breed to which they belong. The indications are that the stimulation to give large quantities of milk may be inherited independently of size. An undersized cow with a great stimulation to give milk

[6] U.S.D.A. Circular 114

is limited in her capacity to digest food and cannot compete with a larger animal that has stimulation to give milk to the same degree and has also the capacity and strength to handle the feed necessary for high milk production. Size and strength then are desirable but alone do not indicate ability to produce milk. Selecting a dairy cow on the basis of size alone would be poor policy, although high-producing cows usually have good size. There is no relation within the breed between the size of the animal and the richness of the milk.

Intervals Between Milking. When cows are milked twice a day at twelve-hour intervals, the composition of the milk usually varies but little, although there is a tendency for the milk from the evening milking to be higher in fat content. Copeland (cited by Turner)[7] gives the records of the American Jersey Cattle Club showing an average fat test of 5.23 per cent for morning milk and 5.50 per cent for evening milk in 821 two-day tests; of these 269 gave the highest test in the morning and 498 in the evening. If the intervals are unequal, as would be the case when the morning milking is done at 5 A.M. and the evening at 7 P.M., the yield of milk will be considerably higher in the evening following the longer interval and the fat content noticeably higher in the morning after the shorter interval. The variation in fat percentage may be from 0.5 to 1.0 per cent under conditions as mentioned. Copeland reported the results of 1,515 tests when there were three milkings a day; these showed 705 cases with highest test (av. = 5.55 per cent fat) at noon, 491 cases with highest test (av. = 5.41 per cent fat) in the evening; and only 232 cases with highest test (av. = 5.01 per cent fat) in the morning. The milk production averaged highest in the morning and lowest in the evening. These variations must be understood when sampling milk for testing. A sample taken from a single milking may be very misleading.

Variations from Day to Day. Marked variations in the fat percentage often occur in the milk from the same cow from day to day. Sometimes the cause for such variations may be recognized, but our knowledge of milk secretion is still too incomplete to give a satisfactory explanation in many cases. Table 49 shows typical variations in the yield of milk and the fat percentage from milking to milking.

[7] Turner, Missouri Agricultural Experiment Station Bulletin 365 (1936).

Where either three or four milkings a day are shown, the animal was under official test The others represent ordinary conditions with two milkings a day

Examples could be given that show much wider variations It is impossible to give any definite limits to the extent of the variations that may occur It should be kept in mind in this connection, as pointed out in another paragraph, that certain variations in fat per-

Table 49 Variations from Milking to Milking in Milk Yield and Fat Percentage

DAY OF TEST	BREED	FIRST MILKING		SECOND MILKING		THIRD MILKING		FOURTH MILKING	
		Milk	Fat	Milk	Fat	Milk	Fat	Milk	Fat
		Lbs	%	Lbs	%	Lbs	%	Lbs	%
1	Guernsey	5.6	4.0	7.7	5.0	6.0	4.6	6.2	4.1
2		6.8	3.4	7.3	5.3	6.3	4.9	7.8	6.0
1	Guernsey	5.6	4.0	7.7	5.0	6.0	4.6	6.2	4.1
2		6.8	3.4	7.3	5.3	6.3	4.9	7.8	6.0
1	Jersey	12.1	5.0	11.3	6.2				
2		13.6	4.2	11.5	5.2				
1	Jersey	13.0	5.1	7.5	7.0	11.7	5.6		
2		11.3	4.8	7.8	6.7	9.4	4.0		
1	Holstein	24.2	3	28.4	3.8	26.2	3.7	25.2	3.7
2		27.8	4.1	26.6	4.0	25.9	3.6	26.0	3.6
3		26.0	4.0	24.3	4.1	23.2	3.6	25.2	4.1
4		23.1	4.0	24.9	4.2	24.2	4.1	22.8	3.7
1	Holstein	19.5	3.4	21.1	3.0				
2		20.5	2.3	14.0	2.2				
3		24.7	3.4	14.0	2.4				

centage, especially, occur with the hour of milking For example when a cow is milked four times daily the highest fat test usually comes at the milking preceding midday For this reason, when considering variations from milking to milking the comparisons should be made with other milkings made at the same hour Compared in this way, a variation of one half of 1 per cent would be common and of 1 per cent not unusual

Bitter or Rancid Milk It is not uncommon for the milk of certain cows to have an abnormal taste and odor These troubles most often attract attention only when one or two cows are kept as a family milk

supply. However, the same condition occurs frequently in the milk of cows in larger herds, but may not be noticed on account of dilution by mixture with that from others. The so-called bitter, rancid condition is limited with few exceptions to cows that have been in milk several months and usually when they are advanced in pregnancy. It rarely occurs when cows are on pasture. The milk has a peculiar taste described by some as salty, by others as bitter. An increased chloride content of such milk has been demonstrated. The lactose content of such milk may be somewhat low. After a few hours a pronounced odor of rancid butter is noticed. Milk in this condition is not in any degree unwholesome but so objectionable in odor and taste that it is worthless. The cream from such milk is churned with great difficulty and sometimes cannot be churned by any method that can be devised.

The bitter, rancid trouble is not, like most abnormal tastes which develop in milk, usually caused by the action of bacteria but by one of the enzymes known as lipase, which is secreted in the milk and which causes a decomposition of the fat resulting in the rancid odor.[8] Fat-decomposing bacteria which often inhabit the udder may sometimes be the cause. There is evidence that milk always contains a potential lipase which may be activated under proper conditions (such as shaking at proper temperature); if this is correct it is evident that at times the enzyme is secreted in a highly active state. The only known method of preventing the development of bitter, rancid milk is to pasteurize the milk immediately after milking. Prompt refrigeration of the raw milk and holding at low temperature are of no benefit because the enzyme is active at low temperatures.

Stale, Oxidized Milk. Another defective flavor which sometimes develops in properly refrigerated milk from individual cows is the "stale," "tallowy," "cardboard" flavor. It is also referred to as "oxidized" flavor. The condition is intensified by contamination of the milk by metals, especially copper, which may occur in pasteurizing and other dairy equipment. Thus pasteurization of the milk will not help the situation; indeed it may indirectly augment it. It has been found that development of lactic-acid-producing bacteria

[8] Palmer, *Journal Dairy Science* 5.201–11 (1922).

counteracts the tendency for milk to become "oxidized," so that pasteurization by destroying helpful organisms may aid rather than hinder the undesirable situation

Most "oxidized' market milk is due almost solely to copper equipment in the milk plant and cannot be attributed to the cow or to faulty management on the farm The milkman and the housewife together may be innocent contributors to this defect in market milk, the former by leaving the milk bottles on the doorstep where they are exposed to the sunlight and the latter by failing to put them in the refrigerator promptly It is well known that direct sunlight acting on milk in ordinary milk bottles greatly accelerates the chemical changes resulting in the off-flavor However, the cow herself may be to blame, for reasons not yet clearly understood Such milk may become intensely "tallowy," on holding for twenty-four to forty-eight hours at low temperature, this flavor is not explainable on the grounds of breed, stage of lactation, pregnancy, or bacterial infection from the udder It is generally agreed that the trouble occurs only when cows are on dry feed, and therefore usually in the winter when the normal more prompt refrigeration also contributes to the situation as already explained Still, as a rule, only a few cows in a herd receiving the same dry feed produce the potentially tallowy milk

There is evidence that oxidation changes in the fatty constituents are responsible for the bad flavor Although the milk fat itself eventually may become involved, the first changes occur in the fatlike substances which form a part of the surface of the fat globules and likewise occur in the skim milk or plasma portion of the milk

There is not complete agreement regarding the cause of the trouble or the lack of it The existence in milk of a natural fat-oxidizing enzyme called *oleinase* has been postulated and is supported by considerable evidence Others believe that an upset in the natural oxidation-reduction potential of the milk is to blame The prevention of the trouble when certain feeds are given and when the cows go on pasture is held to be due to an increase of anti-oxidant substance in the milk from these feeds, but there is no conclusive evidence that the substances which have been held responsible, such as ascorbic acid (vitamin C) and carotene, are in reality involved On the

contrary, the ascorbic-acid content of milk is essentially constant regardless of the feed, and the carotene goes only into the milk fat itself, which is not the first constituent of the milk attacked when tallowy flavor develops.

Seasonal Variation. Another factor causing variations in the composition of milk is the season of the year. Farmers selling milk according to the Babcock test generally note that the test is lower in summer than in winter. The decline in test usually begins in the spring, and the rise generally occurs in the fall.

The mistake has often been made of assuming that this decline in test during the summer months is the result of the feed. The fact that the test is the lowest during the period when the grass is the best, in early summer, and that it shows a tendency to increase toward winter, when grain feeding begins, is easily interpreted to mean that the grass is the cause of the depression. Experimental work has shown that this is an error. The same decline in test during the summer and the increase in the fall have been found to occur in the same manner with cows receiving a typical winter ration throughout the summer and having no access to pasture grass. The tendency is for the tests to reach the low point in early summer, usually June, and the highest point in December or January.

Figure 71 shows the average fat tests, by months, of groups of Jersey cows freshening in December, March, June, and August. The data were compiled by the original author from records of the Missouri and Iowa station herds. These graphs show that the group calving in March reach a low point in June and July, then rise sharply towards winter. Similar data not given in Figure 71 show that cows calving in any month from November to April show the same decline in June and July, followed by a sharp rise. The group starting in June begins practically at the low point and increases toward winter. After December is passed there is a slight tendency to drop. This drop would be greater were it not for the counteracting effect of the tendency to increase toward the end of the lactation period. Other data not presented for cows freshening in July show essentially the same result. Cows calving in August, shown in Figure 71 (and in September, not shown in the figure), definitely start at the low point, and

the test rises rather sharply for the first few months, when it levels off until hot weather the following summer The fat test of the group freshening in December starts at a fairly high level, where it remains until the hot weather decline beginning in May, this is followed by a rapid rise to the end of the year

In studying these graphs it should be kept in mind that there is a strong tendency for the test to increase near the close of the lactation

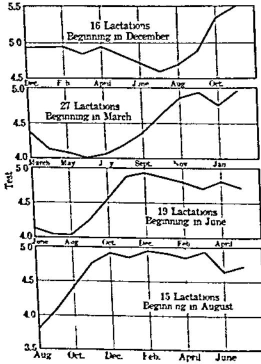

FIG. 71 Graph showing variations in fat test due to season of calving.

period When this stage comes in October, November, and December, when the test is also increasing because of the season, the rise in test is most rapid

When the lactation period ends in June or July the seasonal effect overcomes the influence of advanced lactation, causing the test to decline as lactation closes When the lactation comes to a close in February to May, as a rule the test remains about stationary during the last four months of the milking period Graphs showing the effect

of season and stage of lactation on the fat percentage in the milk of Guernsey cows have been published by Turner.[9]

The effect of the season is apparently the result of weather conditions, especially the temperature. It is found that during a period of hot weather the percentage of fat is depressed, while if the conditions are the reverse the test is increased. This intensity of the effect of the season exerted through weather conditions varies with the locality. It is apparently more marked in the southern than in the northern part of the United States. Its practical importance is primarily that it explains the low tests of summer, which, as noted, are often attributed erroneously to the feed.

The results of the seasonal effects are especially noticeable with high-producing cows on official test. The summer tests under these conditions are often very disappointing. It also has a bearing on the best time of year to have cows freshen. It is found that fall calving gives a slightly higher test for the year than does spring calving, because it brings the highest milk yield and the highest test at the same time.

Solids-Not-Fat Content. Lythgoe[10] first called attention to the fact that not only the fat but also the solids-not-fat of milk is lowest in summer. White and Judkins[11] showed for the Storrs station herd milk that low solids-not-fat in summer coincided with high temperatures, as did also the low fat, the low solids-not-fat lagging somewhat behind the low fat in time of appearance. Similar results were reported by Jacobson[12] for 100,000 samples of farmers' milk coming into a Boston milk plant.

These facts are important in connection with the problem the farmer has in producing legal milk. They complicate the established fact, not recognized in legal definitions of milk, that the solids-not-fat of milk varies rather widely for samples of milk having the same fat content. The solids-not-fat content required in many states, as judged by the legal definitions for fat and total solids, is often impossible of attainment. This may well be expected from the knowledge that the

[9] Missouri Agricultural Experiment Station Bulletin 365 (1936).
[10] Lythgoe, *Journal Industrial and Engineering Chemistry* 6:899 (1914).
[11] White and Judkins, Storrs Agricultural Experiment Station Bulletin 94 (1918).
[12] Jacobson, *Journal Dairy Science* 19:171 (1936).

correlation between the percentage of fat and the percentage of solids-not-fat in different samples of milk is not exceptionally high.

Stage of Lactation and Milk Yield. The point during the lactation period at which milk production normally reaches its highest level, and the rate of normal decline are of concern to the practical herdsman. Considerable individual variation from any average is inevitable. Certain cows, as the result of inheritance, do not hold up in milk as well as others do. The important relation of feed should also

Table 50. Relation of Stage of Lactation to Milk Yield

Month of Lactation	25 cows on official test: Average Daily Milk Yield Lbs	25 cows on official test: In Terms of Percentage	35 cows calving within 12 months: Average Daily Milk Yield Lbs	35 cows calving within 12 months: In Terms of Percentage
1	47.5	87.1	32.9	99.6
2	54.5	100.0	33.0	100.0
3	53.0	97.2	30.3	92.0
4	48.7	89.4	28.4	86.0
5	45.5	83.5	27.0	82.0
6	43.7	80.2	24.7	75.0
7	41.0	75.2	23.4	71.0
8	38.5	71.0	22.7	69.0
9	36.7	67.3	21.1	64.0
10	34.7	64.0	17.1	52.0
11	32.5	60.0	11.3	34.0
12	29.8	55.0	3.8	11.5

be emphasized. Too often a cow is said to lack in persistency when she is really doing all she can with the feed received. The heavy-milking cow is often underfed when she is fresh because nature, to make sure the calf will not suffer, has arranged for the fresh cow to continue to give milk freely for a certain time even if deficient in feed, making up the deficiency from her body. The normal rate of decline in milk during the lactation period can be observed only when the cow concerned has at all times sufficient feed to supply the nutrients for the milk she is producing.

Table 50 gives data showing the average milk production for two groups by months during the lactation period.

One group includes cows under official test conditions, and the other represents good farm conditions where the animals freshen again within twelve months. The results are also expressed in terms of percentage, the highest month being represented by 100 per cent. Official test conditions include three or four milkings daily and delayed breeding. As a result of these conditions this group shows less decline as the lactation period advances. The results are also shown graphically in Fig. 72.

It will be noted that the highest milk yield for both groups is reached the second month. From this point on to the eighth month

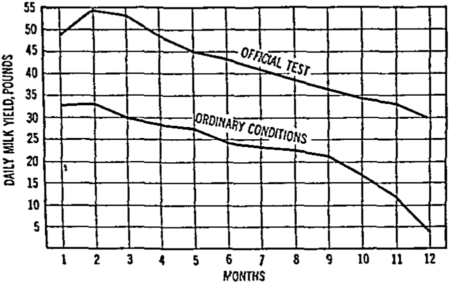

FIG. 72. Graph showing stage of lactation to milk yield

the decline is much the same. From the ninth to the twelfth month the decline is decidedly more rapid for the group which calved again within the twelve-months' period. Cows that make exceptionally high official records for a year generally hold up somewhat better during the last six months than is indicated by the average figures given. By using the percentage figures given, it is possible to estimate approximately what a certain animal will produce at different stages in her milking period. It should be kept in mind that these figures represent the special dairy breeds. Dual-purpose breeds are as a rule less persistent milkers, and the rate of decline for these breeds is more rapid.

Stage of Lactation and Fat Percentage. The influence of the

stage of lactation upon the fat content of milk is often overestimated Furthermore, it is influenced by several other factors Table 51 gives data which will serve as a basis for discussion The data are illustrated in Fig. 73 These averages are made up regardless of the month of freshening, and the numbers included are large enough to eliminate the tendency to vary with the season The first group includes thirty-four cows representing four breeds, kept under conditions typical of the best farm practice, and all of which calved again within twelve months The fat content of the milk from this group

Table 51 Relation of Stage of Lactation to Fat Percentage

MONTH OF LACTATION	34 COWS CALVING WITHIN 12 MONTHS	[illegible]64 HOLSTEINS OFFICIAL TEST	3 763 GUERNSEYS OFFICIAL TEST	3 154 LACTATIONS ALL BREEDS
1	4 0[illegible]	3 55	4 63	4 31
2	3 94	3 36	4 59	4 28
3	4 06	3 25	4 71	4 35
4	4 00	3 29	4 85	4 44
5	4 10	3 27	4 97	4 54
6	4 10	3 29	5 08	4 62
7	4 17	3 34	5 16	4 69
8	4 20	3 38	5 22	4 76
9	4 20	3 47	5 29	4 85
10	4 50	3 5[illegible]	5 39	4 88
11	4 59	3 [illegible]	5 49	4 96
12	4 [illegible]0	3 63	5 60	5 00

remained practically the same for the first four months From the fifth to the ninth month a slight increase is noted, followed by a more rapid increase to the end of the milking period In general, it may be said that under the conditions typical of good farm practice there is little if any increase in fat content until the point is reached where the decline in milk production is rapid

Cows under official test conditions show a somewhat different result. The Holsteins—and the same is true for the Ayrshires, although no figures are given—show a marked decline from the first to the third month, running about the same to the eighth month, after which there is a tendency to rise, until at the tenth month the fat percentage

is about on a par with the first month. The high fat percentage in the beginning is the result of having the cows in high condition, as explained in another paragraph. These same groups of animals would usually increase later to over 4 per cent during the period when the milk production is declining rapidly.

The Guernsey records made under official test conditions show only a slight decline after the first month. For some reason this breed

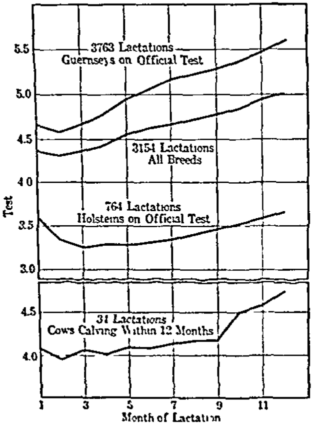

FIG. 73. Graph showing stage of lactation to fat percentage.

and the Jerseys as well do not show an increase in fat content of milk as the result of high *conditioning in preparation for official testing*. The last column shows an average of all studied, 3,154 lactation periods, some under official test conditions, others not. These show a slight decline from the first to the second month, followed by a gradual increase to the twelfth month.

As pointed out in another paragraph, the seasonal influence modifies the variation in fat content of milk materially and, in fact, is a

greater factor than stage of lactation except for the rapid increase as the cow is going dry

Effect of Gestation It is a matter of common observation that a milking cow that is not bred or that fails to become pregnant holds up in milk production better than one that is carrying a fetus The cattleman usually attributes this falling off in milk to the tax upon the animal commonly assumed to accompany gestation The decline in milk production after the animal reaches about six months in gestation is the result of the hormones produced by the ovaries, which exert an inhibiting effect on the secretion of the lactogenic hormones produced by the pituitary gland

Table 52 Effect of Gestation Upon Milk Production

	CALVING WITHIN A YEAR	DELAYED BREEDING
Number of cows	19	19
Days in milk	305	579
Milk yield for entire period lbs	6 508	10 032
Milk yield 365 days lbs	6 508	7 650
Fat yield for entire period lbs	293	489
Fat yield 365 days	293	349

The effect of gestation upon milk secretion begins to be noticeable when the period is about five months along The effect of gestation upon milk production is shown in Table 52 and graphically in Fig 74 These data were compiled from the records of nineteen cows for which milk and fat records were available for a lactation period during which they were milked twice daily and bred to calve again within twelve months for a second lactation period, but for some reason they did not become pregnant and continued in milk for at least fifteen months The data show that these cows average 293 pounds of fat during the lactation period, which was followed by calving within a year while the production was 349 pounds within the year when breeding was delayed In this case delayed breeding resulted in 19 per cent more milk during the twelve months' period The production of the group whose breeding was delayed would be decidedly the lower of the two the following year

Delayed breeding is justified when it is desirable to secure the maximum production, as when making official tests. When the production of market products is the object, the best plan is to have the cows freshen at intervals of about twelve months.

Feed in Relation to Yield and Richness. The amount of milk a cow produces depends upon two things: first there are the internal factors which are the result of inheritance, and second there are the factors of environment, that is, the feed and management. It should be kept in mind that feed alone cannot cause a cow to give milk beyond the limits of her inherited ability. The extent to which she

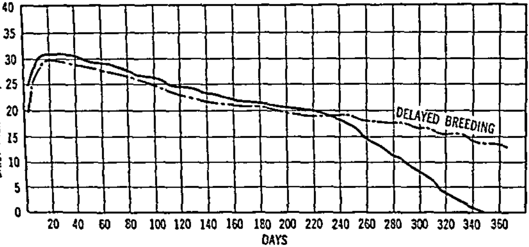

FIG. 74. Graph showing effect of gestation upon milk production.

can reach her inherited ability and can use feed for this purpose may be looked upon as the result of an internal stimulation. Within the limits of her inherited capacity, the amount of milk is closely dependent upon the feed received and the environment in which she is kept.

It would seem reasonable to assume that the richness of the milk might be influenced by the feed consumed by the animal. This question has received much attention in the past by experiment stations in this country and in Europe, and the evidence has seemed conclusive that the fat percentage of the milk cannot be changed permanently by any method of feeding. Certain experiments have shown that sudden changes in the ration—for example, greatly increasing the protein or oil content of the ration, or the use of some of the

new protein compounds such as thyroprotein—may result in a small fat increase for a few days with some individuals, but with others no effect is produced, and in any case the results have been only temporary Such has been the status of knowledge of the major factors affecting the butterfat content of the milk of dairy cows More recently certain experiments with ground feed and limited roughage seem to indicate some unknown factors associated with abnormal roughage conditions which may cause a noticeable drop in the fat percentage of milk produced under these conditions In certain sections of the west and south where drought or dust-bowl conditions greatly restrict pasturage and roughage, the fat content of milk from entire herds and sections has dropped and remained low until normal roughage conditions returned Research work at the Florida Experiment Station[13] has also shown a "roughage factor" as yet unknown as having an adverse effect on fat percentage

Wing and Foord[14] made an interesting study of the relation of liberal and scant feeding to milk production, covering four years and including twenty-one cows A record of the milk production and the fat was kept for a lactation period on a farm where the feeding conditions were very poor At the end of the period, ten of the cows were brought to the University Farm and fed liberally for two years, they were then returned to the farm and a record was secured for the fourth year The seven cows that were continued the four years showed the following results

	LBS MILK YIELD	FAT PERCENTAGE
On farm scant ration	3 340	4 40
University Farm good ration	6 383	4 65
On farm scant ration	4 492	4 43

The good feed and care resulted in nearly double the amount of milk produced under the poor feeding conditions on the farm The result of the good treatment was carried over to some extent the fol

[13] Becker and Arnold *Guernsey Breeders Journal* Jan 1 1954

[14] Cornell University Agricultural Experiment Station Bulletin 222 (1904)

lowing year when the herd was returned to the original farm conditions. The richness of the milk, however, was not increased to any appreciable extent by the better feed.

First and Last Milk Drawn. It is a well-established fact that the first milk drawn contains a very low percentage of fat and that the last or the strippings, as ordinarily termed, are very rich in fat.

Table 53 is a summary of data from seven cows representing four breeds and gives the results of a complete chemical analysis.

These figures show that the difference between fore milk and strippings is confined to the fat, and that this constituent shows a striking difference. It was also observed that the variation in fat content between fore milk and strippings is usually the greatest with heavy-milking cows.

Table 53. Composition of First and Last Milk Drawn

	TOTAL PROTEIN PER CENT	SUGAR PER CENT	FAT PER CENT	ASH PER CENT	TOTAL SOLIDS PER CENT
First milk	3 58	5 30	1 87	0 75	10 67
Strippings	3 38	5 33	6 28	70	14 86

The milk of a Jersey cow producing thirty-six pounds daily contained 1.59 per cent of fat in the fore milk and 5.9 in the strippings, while the milk from a cow of the same breed producing seven pounds daily contained 3.07 per cent of fat in the fore milk and 4.91 in the strippings.

The practical value of these facts is to make it clear why the cow should be stripped when milked in order to secure the maximum amount of the high-testing milk. The last pint of milk drawn is equal to the first two quarts in fat contained.

Incomplete milking is also detrimental because if practiced continually it hastens the decline in lactation. Thorough massage of the udder before milking is begun decreases greatly the difference in fat test between the fore milk and the strippings. The high fat content of strippings is believed to be explained, in part, by the possibility that

only certain of the gland cells produce fat and that the release of fat from these is greatly increased as the pressure of milk in the udder declines as the milk is withdrawn

Condition of Flesh at Calving Good practice requires that the cow be in a strong, vigorous condition at time of freshening and have considerable surplus flesh as a reserve The milk yield, especially in the early part of the lactation period, depends to a considerable extent upon this point

Within the limits of ordinary practice the fat percentage is not influenced as much by the physical condition at this time as in the milk yield However, when the conditions are rather extreme, a pronounced effect upon the fat percentage results A cow which calves in a decidedly fat condition may for the first twenty to thirty days have a fat test very much above her normal for the year and, likewise, decidedly more than would be found if she were in a thin condition In some cases the effect may continue for as long as three months The possibility of influencing the test in this manner has appeared as one of the abuses in forcing cows to abnormal records in official testing

A single, rather extreme case will suffice to illustrate the possibilities The original author, in conducting the first experiments establishing this factor, secured an average fat percentage for seven days of 5 1 from a Holstein cow fattened to excess before calving Her average for the year was 3 3 The following year the same cow, calving in moderate flesh, averaged 3 6 per cent of fat for seven days while for the year the average was 3 3 or the same as the preceding year

Influence of the Heat or Estrum Period The question is often raised whether the milk produced during the period of heat or estrum is suitable for human food, especially for infants or invalids It is recognized that any unusual excitement or exercise may change the composition of the milk, especially in regard to fat content However, the estrum is a perfectly normal function of the animal and should hardly be classed as unnatural or abnormal, and it is doubtful if any harmful effect would be produced upon the milk

The question has been studied by a number of investigators The

facts as brought out by a rather extensive investigation by Doane[15] indicate that in some animals there is no effect upon the fat content of the milk while with others the reverse may be true. Two cows used in his experiments increased the fat content of the milk over 1 per cent while the other three showed no variation. The other constituents were not affected, and, so far as chemical analysis showed, the milk was practically normal and fit for consumption. It was recognized, however, that the possibility existed of some substances being present that might be detrimental, but which the chemical analysis would not reveal. Recent work revealing the nature of the estrum-producing substances shows that they would be harmless even if they were secreted in the milk. Among the herdsmen in charge of cows on official test the opinion is commonly held that the fat test is increased during the period of estrum. Copeland[16] reports 211 observations on Register of Merit Jersey cows in which 43 cases showed both milk yield and fat percentage increases during estrum, 58 cases when both declined, 73 cases in which milk yield declined slightly and fat test increased slightly, 27 cases in which the reverse was true, and 10 cases when neither milk yield nor fat percentage changed.

Influence of Drugs. The interest in the possible use of drugs as a means of stimulating milk production arises largely in connection with the phenomenal milk and fat records which have characterized official testing in recent years. The assumption is sometimes made that those responsible for the care of cows producing such astonishing quantities of milk and fat resort to the use of drugs or some secret means of producing these records. However, there is no evidence that it is possible to use drugs for this purpose. On the contrary, most of the experimental evidence available shows rather a depressing effect from drugs.

Hayes and Thomas[17] reported experiments in using various drugs and tonics. One tonic was a mixture of oil meal, saltpeter, Epsom salt, gentian, fenugreek, powdered charcoal, and sulphur. They also fed air-slaked lime, Fowler's solution of arsenic, and a tonic containing

[15] Maryland Agricultural Experiment Station Bulletin 95, p. 25 (1904).

[16] Cited by Turner, Missouri Agricultural Experiment Station Bulletin 365, p. 22 (1936).

[17] *Journal Agricultural Research*, 19:123–130 (1920).

sulphide of antimony, sodium bicarbonate, and ginger The only significant increase in milk production followed the use of the air-slaked lime Some of the drugs depressed milk secretion, and the others were without effect

McCandlish[15] concluded that drugs cannot be relied upon to give an increase in milk flow He tried alcohol, caster oil, pituitrin, pilocarpine, aloes, and Epsom salt—with negative results

Rapid advances being made in the chemistry of the hormones, including those which control milk secretion, suggest the possibility of their eventual value for stimulating milk production under some conditions One of these is the thyroprotein or iodinated casein compounds They are inexpensive, and some effort has been made to place them on the market for commercial use They so far have not been sanctioned by the Breed Associations for use in official testing or by dairy officials as they may be dangerous if used in warm weather or with cows in advanced gestation, or if improperly used, and the milk produced may be dangerous to use

Relation Between Daily and Yearly Production The only means of knowing what a cow will produce in a year is to keep systematic records Estimates of yearly production based upon the results of a few days are certain to have at best a limited value As is often the case an average can be determined that will represent reasonably well the results from a group Individuals, however, will vary widely from the average

However, in a herd where uniform conditions of feeding and care are maintained, there is a fairly definite relation between the highest point of the lactation period and the total production, and figures showing this relation have some value

Table 54 brings together data showing this relation as expressed in averages The figures given by breeds are averages compiled from the records of 250 registered cows, milked twice a day and freshening again within twelve months These animals all received good feed and care In compiling these data the individuals were placed in groups according to their average daily production for the month having the highest total milk during the lactation period It will be noted that

[15] *Journal Dairy Science* 1 475–486 (1918)

some irregularities appear in the rate of increase from group to group. These irregularities would largely disappear if figures were available for a group of sufficient size

An examination of the data in detail showed that about 90 per cent of the total records for each group came within the figures given in the column, indicating the probable yearly production. The table shows, for example, that a cow averaging between 25 and 30 pounds of milk daily should be expected, at her best, to produce between 5,500 and 6,500 pounds for the year; a daily average, at the best, of

Table 54. Relation of Daily Milk Yield to Yearly Production, Twice-a-Day Milking, Calving Within Twelve Months

AVERAGE DAILY YIELD HIGHEST MONTH	AVERAGE YIELD FOR LACTATION PERIOD				PROBABLE YEARLY MILK PRODUCTION
	Holstein	Ayrshire	Guernsey	Jersey	
Lbs	Lbs	Lbs	Lbs	Lbs	Lbs
15–20	3,787	3,985	3,914	3,600	3,000– 4,500
20–25	5,480	5,158	4,614	5,498	4,500– 5,500
25–30	6,864	5,577	5,996	6,172	5,500– 6,500
30–35	7,079	6,367	6,548	7,133	6,500– 7,500
35–40	7,880	6,913	8,052	8,010	7,500– 8,500
40–45	9,598	8,557	8,900	9,385	8,500– 9,700
45–50	10,190	10 800			9,700–11,000
50–55	11,435				11,000–12,000
55–60	12,693				12,000–13,000
60–65	13,118				13,000–14,000
65–70	14,851				14,000–15,000

40 to 50 pounds indicates 8,500 to 9,700 for the year. The figures seem reasonably uniform for the four breeds included It should be added that the animals supplying these data had excellent treatment, and the estimated yearly production in proportion to the daily yield is therefore higher than for many herds.

Table 55 gives similar data based upon the official records of 350 purebred cows. The records were grouped according to the average milk yield for the highest month The average milk yield of the groups for the year is given for comparison The last column of the table gives the estimated yearly milk yield based upon the daily productions

as given. Official test records are the results of a combination of a high-class cow and of expert care and management. For this reason they are subject to wide variations in the relation between daily production and yield for the year This is especially true in the groups showing the exceptionally high daily production. For these reasons the table should be looked upon as indicating the relation between daily and yearly production in a general way only.

Table 55 Relation of Daily Milk Yield to Yearly Production (Official Test Conditions)

AVERAGE DAILY YIELD HIGHEST MONTH	AVERAGE MILK YIELD			PROBABLE YEARLY MILK PRODUCTION
	Holstein	Guernsey	Jersey	
Lbs	Lbs	Lbs	Lbs	Lbs
20–25			6,112	6 000– 6,500
25–30		8,030	6,770	6 500– 8,000
30–35		9,394	8 800	8,000– 9,500
35–40	10,745	10,935	10,505	9,500–11 000
40–45	12,722	12 035	11,513	11,000–13,000
45–50	13,993	12,883	12,515	12,000–14,000
50–55	15,675	14 362	14,254	13,500–16 000
55–60	17,092	16 440	15,337	15,000–17,500
60–70	18,354	17,599		16 500–19,000
70–80	20 096			18,500–21,000
80–90	21,063			20,500–23,000
90–100	23,811			22,000–25,000
100+	28,821			24,000–29,000

Official vs. Ordinary Milk Production Records. In recent years official testing of purebred dairy cows has become general and the records of milk and fat production are given wide publicity. Such records are used as the basis of breeding Fifty years ago a production of 14 pounds of butter in a week, or 500 pounds in a year, was sufficient to justify a widespread reputation for a dairy cow. Now records over 1,000 pounds of fat in a year are too common to attract attention An important question arises in this connection as to what extent these greatly increased records of recent years are the result of better breeding and to what extent they are to be attributed to more skill in feeding and management

Important questions also arise in connection with the records from the dairy herd improvement associations and their relation to records from official test conditions. Dairy herd improvement associations have become an important factor in the improvement of dairy cattle. The records of these associations, however, are decidedly below those made under conditions of advanced register testing. The question

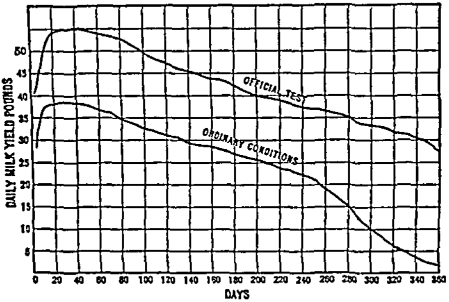

FIG. 75. Comparison of production under good farm conditions and official testing This chart shows the average daily milk production during two years for a group of 41 cows, including four breeds The curve marked "ordinary conditions" shows the production during the lactation period under good farm conditions, which includes twice-a day milking, and freshening again within 12 months The line "official test" represents the production of these same cows under official test conditions which include three or four milkings daily, extra care, and delayed breeding The official test conditions gave an increase of 70 per cent in milk over good farm conditions

arises as to how far it is fair to compare them, and if the wide range in records between the two is due to the quality of the animals or to a difference in feed and management.

There is no question that greatly increased milk and butterfat records in recent years are to be attributed in no small part to the results of intelligent breeding; the greater factor, however, is more skill in feeding and management. The cow under test for advanced registration is first of all prepared for the test by liberal feeding preceding the time of calving While the test is under way she is milked three or

four times daily, breeding is generally delayed the best possible ration is provided, and she receives the most careful attention that a skilled herdsman can give Under typical farming conditions where most dairy herd improvement testing is done, the milking is done twice daily, and the cow is expected to drop another calf within twelve months The feed and care vary widely, but the cow at best receives far less attention than under official test conditions

The results of a study made concerning the relation between milk production under official test conditions and ordinary conditions are given in Table 56 The data used are from the records of the Minnesota, Nebraska Storrs, and Missouri experiment stations Records were available for forty-one cows that had been kept one year under typical conditions of official testing and another year in the same herd under good practical conditions, such as are usually maintained on the best farms and which are typical for cows tested in cow test associations These cows were milked twice a day and calved again by the end of twelve months Table 56 shows that the cows under official test conditions average 70 7 per cent more milk and 64 9 per cent more fat than when milked twice a day and calving again within the year The production under ordinary conditions, it should be noted was excellent, indicating that cows that make good records under official test conditions are unquestionable superior animals and may be relied upon to give a liberal production under ordinary condi-

Table 56 Comparison of Results from Cows under Official Test Conditions and Ordinary Conditions

BREED	NUMBER ANIMALS	OFFICIAL TEST CONDITIONS		ORDINARY CONDITIONS	
		Milk	Fat	Milk	Fat
		Lbs	Lbs	Lbs	Lbs
Jerseys	17	10 213	531	6 554	331
Holsteins	18	18 928	618	10 456	366
Guernseys	3	12 197	552	6 983	328
Ayrshires	3	12 222	449	7 871	293
Average	41	14 331	564	8 395	343

tions. Taking these figures as representative, it is safe to expect the production of a cow under ordinary conditions to be about 58 per cent of her official test. These results suggest that at times there may be a tendency to overrate cows with official records in comparison with cows tested under cow-test association conditions.

An analysis of the records reported in Table 56 shows that the difference between records made under official test conditions and ordinary conditions is greatest with those making the highest records under official test. The forty-one animals were divided into two groups, those producing more than 600 pounds of fat and those producing less. The comparison is as follows:

	NUMBER OF ANIMALS	ON OFFICIAL TEST AVERAGE FAT PRODUCTION	UNDER ORDINARY CONDITIONS AVERAGE FAT PRODUCTION
		Lbs	Lbs
Above 600 lbs fat in official test	17	673	363
Below 600 lbs. fat in official test	24	487	328

The percentage of increase in milk for the first group was 90.5 and for the second 52.9. These results are as should be anticipated. The situation is that the higher record cows have the greater capacity for milk production, and under conditions of official testing have opportunity to make use of all their capacity. Under ordinary conditions, other factors set the limits, and a cow that has the ability to produce 700 pounds of fat under the favorable conditions of official testing may not under ordinary conditions produce much more than one that is capable of making an official record of only 500 pounds of fat. The large records made under official test conditions are the result of a cow with outstanding ability as a milk producer combined with the most favorable environment.

Influence of Age upon Richness of Milk. A large amount of data are available on this point and the facts are well established.

Table 57 gives a compilation of data from official testing records.

Table 57 Relation of Age to Fat Percentage (Results from Official Tests)

AGE	HOLSTEIN	AYRSHIRE	GUERNSEY	JERSEY	BROWN SWISS
Years	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Over 5	3 42	3 91	5 00	5 27	3 93
4–5	3 39	3 95	4 01	5 36	4 02
3–4	3 39	4 00	5 04	5 45	4 06
2–3	3 42	4 05	4 98	5 37	4 01

These figures are especially valuable on account of the very large number included—over ten thousand for one breed alone These data show no variation in fat percentage of any consequence due to age, within the limits usually included by cows on official test

Table 58 gives the results of a compilation from the records of forty-one Holstein and seventy four Jersey cows kept under good con-

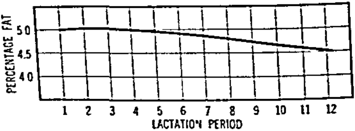

FIG. 76 Influence of age upon richness of milk The chart shows graphically the data from the Jersey breed The age of the cow has practically no effect upon the richness of her milk during the limits of age usually represented by cows in commercial herds After the age of ten or twelve years a slight decline occurs from year to year A Jersey cow testing 5 0 per cent of fat when young will if she continues to milk to the age of fifteen years usually declines to about 4.5 per cent.

ditions but not under official test These data show the same facts as illustrated by the previous table except that the records are extended to older animals The records are for lactation periods and cannot be translated into age with accuracy As a rule the cows supplying these records calved at the age of twenty-six to twenty-eight months and the intervals between freshenings averaged a little more than a year

The figures show that the richness of the milk remains fairly con

Table 58. Relation of Age to Fat Percentage (Records from cows under ordinary conditions)

LACTATION PERIOD	JERSEYS	HOLSTEINS
	Per Cent	Per Cent
1	4.99	3.30
2	5.04	3.23
3	5.00	3.24
4	4.89	3.29
5	4.97	3.19
6	4.85	3.34
7	4.76	3.18
8	4.63	3.21
9	4.54	3.16
10	4.40	3.10
11	4.22	
12	4.00	

stant, fluctuating slightly with individuals from year to year until the animal is past her prime, when it slowly declines with advancing age.

A heifer having a low test as a two-year-old is sometimes excused on the ground that she is young and will do better when mature. The data show there is no ground for such belief. The facts are that the richness of the milk is a matter of inheritance and is fixed even before the animal is born. Nothing can be done to change it. Selection of the breed of breeding stock from high-testing families and selection of individuals are the means to be used in securing a high-testing herd.

CHAPTER XXIV

Common Ailments of Cattle

This book makes no pretense of giving directions for the treatment of such accidents and diseases as call for the services of the competent veterinarian A brief discussion is given of the most common ailments of cattle that the cow owner should undertake to treat without extensive experience The discussion of tuberculosis and contagious abortion is in the nature of advice for the owner of dairy stock, and is not expected to take the place of expert advice by the veterinarian

Instruments and Medicine Needed Every manager of a herd of dairy cattle should be prepared for the ordinary emergencies that are certain to come If a competent veterinarian is not readily accessible, such preparedness is all the more important The following instruments are the most often needed, and it is advisable to have them on hand and always in clean, sterile condition

Milk fever outfit	Bulb syringe
2 milk tubes of different sizes	Drenching bottle
3 teat plugs of different sizes	Clinical thermometer
Trocar	Mastitis kit

For those with some experience a surgeon's scapel should be added

A liberal amount of a good disinfectant should always be on hand, because frequent use will be found for it For this purpose some of the common coal tar preparations are suitable, or crude carbolic acid, which can be prepared in a 2 per cent solution to be applied to the animal's body or in a 5 per cent solution to disinfect other objects

such as the floor of the barn or instruments. Tincture of iodine is indispensable for disinfecting wounds and treating the navels of new-born calves. It is probably the best general disinfectant for barn use. An abundant supply of Epsom salt should also be on hand, as occasion for using it will come often. In most herds entirely too little use is made of this important medicine. A does of 1 to 1½ pounds of the salt for the grown animal should be the first treatment in nearly all cases of sickness. In every case when an animal shows loss of appetite or sickness, the cause of which is not known, a physic should be given at once and the feed reduced. A second dose after three or four days is often beneficial. If the appetite of the animal has returned, the ration can again be increased to the normal.

Drenching a Cow. The common method of administering medicine to a cow is to mix with water and give from a bottle. This is known as a "drench." When giving a drench, the head of the animal should be elevated by being tied or held by an assistant. The operator stands on the left side, and grasps the nose with the thumb and fingers in the nostrils. The bottle used should be adapted for the purpose, having a long, strong neck such as a wine bottle has. The mouth of the bottle should be inserted in front of the back teeth and rest on the cow's tongue as far back as the middle of the tongue. If the animal coughs, the head should be at once lowered to allow the liquid to escape from the windpipe. If this is not done, the medicine may pass down into the lungs, and cause pneumonia. Unless there is some special reason for doing so, it is not customary to give over 1 to 2 quarts at a time. Unless the herdsman is thoroughly informed regarding the treatment of cattle ailments, he will seldom have occasion to administer by drenching any medicine other than Epsom or Glauber salt except under the direction of a veterinarian.

Tuberculosis. This insidious disease in the past half century has been of the greatest concern to dairy cattle owners as well as to milk consumers. Its ravages in the dairy herds resulted in tremendous financial losses each year, and the use of milk from diseased cows was a menace to the health of the milk-consuming public, because a considerable percentage of tuberculosis in the human family—especially among children—has been due to the consumption of dairy products

from tubercular cows This disease has been the subject of great concern on the part of health authorities and much thought and study have been devoted to perfecting means for its control and eradication inasmuch as no cure has yet been found

How the disease spreads The presence of one diseased animal in a herd at once becomes a menace to the health of all It is impossible to determine just when a tubercular cow becomes a "spreader" but sooner or later she begins to give off the germs of the disease They escape with the slobber from the mouth, in the exhalations from the nose, with the dung—and, in badly affected animals, with the milk If the disease is accompanied by coughing, the germs are sprayed over an extensive area in the minute droplets of moisture discharged by the act of coughing In this manner animals in adjoining stalls may take in the germs by inhalation, or by eating feed which has been contaminated For this reason good barn sanitation and management are important

Common watering troughs, ponds, and drinking holes are also thoroughly contaminated by the discharges of diseased cattle, and serve to spread the infection Another means of disseminating the disease is by feeding milk from tubercular cows to young animals without first pasturizing it This may easily occur when milk is brought back from the creamery and used for calf feeding or from the practice of feeding gargety or unsalable milk to calves

How it affects the animal Tuberculosis in a cow may run its course quickly, resulting in the death of the animal, but this seldom occurs As a rule, it progresses slowly and the animal may have it for years without any indication of ill health All this time the animal is a menace to the health of both the cattle in the herd and the individuals who work with the cattle, as well as those who consume the product The disease may attack any part of the animal s body, but is most common, as with human beings, in the lungs and lymph glands In advanced stages the disease becomes generalized, lesions are present in the lungs, liver, spleen, and lymph glands, and clusters of tubercles frequently form on the membranes lining the chest cavity The udder is also invaded by the organisms, and open lesions in this

organ are sure to result in the presence of large numbers of tuberculosis germs in the milk.

It should be thoroughly understood that it is impossible to judge from external appearances, except in extreme cases, whether the animal is affected or not. Neither can any examination of the milk be depended upon as a reliable test of the presence of the disease. Fortunately we have in the substance known as tuberculin an almost infallible agent for determining the presence of the disease even in the smallest degree.

The tuberculin test. The tuberculin test is recognized as the most practicable and satisfactory way of discovering the disease in living animals. The test consists of introducing tuberculin into the animal and interpreting the results according to well-known standards. Tuberculin is a laboratory product, scientifically prepared, and contains no living tubercle bacilli. No harm can result to healthy animals when it is applied even in much larger quantities than are employed in making the tests. The use of tuberculin should be limited to experts trained for this work.

The different types of test. There are three standard methods of applying the tuberculin test in cattle; the *subcutaneous*, the *intradermal*, and the *ophthalmic*. The intradermal test is almost universal at the present time.

The accuracy of the test. In the early days of tuberculosis testing the question of accuracy was often raised. It has been thoroughly demonstrated that it seldom if ever fails in the hands of a person who thoroughly understands its use and the interpretation of the results secured. The only means for determining the correctness of its diagnosis is the post-mortem examination of condemned animals. These examinations prove that close to 100 per cent of the animals condemned show lesions of the disease somewhere in their bodies.

Nonreacting infected animals. The greatest fault of the tuberculin test is that occasionally an animal affected with tuberculosis fails to react to carefully applied tests and escapes condemnation. The consequence is that she remains in the herd and may be the means of disseminating the disease and causing a serious outbreak when she

becomes a spreader Fortunately this occurs only in a very negligible number of cases It is reason enough, however, for regular retests after sixty days on herds not fully accredited under the accredited herd plan

The accredited herd plan The accredited herd plan was originated in order to afford to those breeders with tuberculosis-free herds the benefits to which they are entitled by reason of their freedom from the disease The work is conducted under the direction of the United States Department of Agriculture Herds which are found to be free from tuberculosis on two successive tests are placed on the accredited list, and a certificate is given to the owner by the State and the Federal Government

The breeder of pure bred stock who can guarantee his animals to be free from tuberculosis finds it a valuable recommendation When new animals are introduced into a tested herd, they should be only those coming from similar herds, or else should be held in quarantine until they have been carefully tested and pronounced healthy In this way the introduction of the disease from the outside is effectively controlled

At the present time the area plan of eradication has been adopted in all counties in all states in the United States and all cattle are being tested and reactors eliminated

It is worth while to observe the progress made by the accredited herd plan recently, as indicated by the following figures In 1952 there were 1,247,587 cattle tested under the accredited herd plan and 8,427,648 under the area plan In this total tested the incidence of reactors was only 11 per cent Many states are now classed as area-free states The percentage of reactors has dropped from 3 7 per cent in 1926 to 11 in 1951 Tuberculosis is definitely under control in the United States This is not true in other cattle sections of the world

The only means of dealing with the tuberculosis scourge are apply the tuberculin test until the herd is free from all reactors, avoid the purchase of animals except from accredited herds, or insist upon a retest after the animals are shipped, and be sure that animals are not exposed to the disease while in transit, by thoroughly disin-

fecting all cars in which healthy stock is loaded, and keeping animals away from stock pens if possible. Tuberculosis can be controlled and eliminated if properly handled.

Abortion. This term is used by cattlemen to indicate the expulsion of the fetus at any time before completion of pregnancy. Abortion may be contagious or noncontagious. The noncontagious cases, which are infrequent, may occur as the result of injury—as from falling or being kicked by a horse or being crowded in a doorway.

It is also known that ergot may cause abortion in cows. This fungus is recognized as black, hard, spurlike growths which protrude from the seeds of grasses at the time of ripening. Rye grass is especially subject to ergot, and ergot is common in bluegrass, especially in low wet places.

When a single case of abortion occurs in a herd, it may be attributed to some accidental cause; but it should best be regarded with suspicion, and close watch should be kept on all females approaching parturition. If other cases occur near together, as a rule it is due to the presence of the contagious disease.

Contagious abortion including Brucellosis. The financial loss incurred by dairymen through the ravages of contagious abortion are much greater than those caused by tuberculosis. In consequence, much painstaking experimental work is now in progress to increase the existing fund of knowledge regarding its nature and the means of its spread, and to develop methods of control. The premature expulsion of the fetus is merely one of the evidences of the presence of the disease, but failure to abort is no indication that a cow or heifer is free from the germs which are responsible for the abortion disease.

The presence of the abortion germ does not induce abortion in all cows. The tremendous losses due to the ravages of this disease are not confined to the calves which are expelled prematurely, but its greatest destruction is wrought by the aftereffects of the action of the disease organisms on the generative organs of infected animals and the loss in milk production. One common sequel of infectious abortion is the retention of the fetal membranes or afterbirth, portions of which may remain in the uterus and decompose. In this condition the uterus is open to invasion by other infections which often result in

permanent inflammation of the membranes of the uterus, chronic enlargement of the cervix or neck of the uterus, cystic degeneration of the ovaries, and the diseases of the Fallopian tubes which convey the eggs from the ovaries to the uterus All these conditions are prone to interrupt the normal reproductive processes and result in permanent sterility, which means the loss of valuable animals from the herd, in addition to the initial loss of the calves and lowered milk production

The cause of abortion disease The usual cause of bovine infectious abortion is a germ discovered by Professor Bang, of Denmark, in 1896, and known as the *Bacterium abortus* of Bang, or Bang's Bacterium It is generally believed that the common bacteria causing the trouble, the *Bacterium abortus*, are taken into the digestive tract through the mouth of the pregnant cow and reach the uterus by means of the circulation Investigations show that at times other species of bacteria may cause abortion, but are usually not highly infectious to other animals The bacteria attack the membranes which surround the fetus and cause a separation of the fetal and maternal membranes, thereby cutting off the blood supply of the fetus and resulting in its premature expulsion from the uterus

The abortion bacterium resides in the placentas of aborting cows, in different portions of the body of the aborted fetus, and in the udders and associated lymph glands of affected cows It occasionally attacks and can be found in the reproductive organs and seminal fluid of bulls It invades the uterus only a short time before the act of abortion or parturition, and rarely persists in that organ for a longer period than three weeks or thirty days after an abortion It may persist in the udders of aborting cows for several years without causing further trouble

The presence of the abortion germ in the body of an animal may be definitely determined by the application of a blood test A positive test is no indication that the animal will abort, but such an animal should be regarded with suspicion and is capable of spreading the infection to other members of the herd even though she herself carry her calf full time and deliver a healthy calf The germs are un-

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doubtedly present in the uterus at the time of parturition, and the fetal membranes and fluids and all discharges from the uterus are thickly seeded with virulent bacteria. Other cows coming in contact with such an animal shortly before or after she calves are apt to ingest some of the discharges, either by licking her or by consuming feed or bedding which has been soiled by these discharges. The principal danger of spread of disease is from the aborting cow or infected cow at time of calving, by the careless handling of the afterbirth and the failure to keep her isolated during that period before and after aborting or calving, when she is giving off active germs from the vagina. Newly born calves from infected cows should be handled so that they have no opportunity to soil the feed or bedding used for the rest of the herd. All bedding from the maternity stalls is classed as infected material. The bull may, in special cases, act as a spreader if bred to a cow before the infection of the uterus has been cleaned up, or if his genital organs are diseased and the germs are given off in the seminal fluid. Infection occurs from the dripping of mucus or fluids from the vaginas of cows after breeding. Another possible source of spread is the milk from cows harboring the germs in their udders. They are present in the milk drawn from such cows, and they may be introduced to udders of other cows on the hands of a careless milker. However, this is considered only a remote possibility as a means of disseminating the disease. In brief, the paramount danger lies in the aborting and positive cows, and with them the critical period is at or near the time of abortion or calving.

Treatment and prevention. No specific cure for infectious abortion has yet been found. However, calfhood vaccination with Strain 19 Vaccine is becoming increasingly recognized as of practical value if carefully handled by a reliable veterinarian and in conjunction with a systematic plan of blood testing of the whole herd. The work to combat the disease under ordinary herd conditions should still first be directed toward the prevention of its entrance into healthy herds, and its control, if found by a regular blood testing program under state and federal supervision.

Rules for the control of abortion. The following recommenda-

tions for the prevention of the entry of contagious abortion into healthy herds, and its control where present, are worthy of serious consideration

Breed and raise your own animals in so far as possible, to avoid the introduction of disease with purchased animals In buying an aged bull or pergnant cows the greatest care should be exercised to make certain that the disease is not prevalent in the herd from which the animals are bought Insist upon a blood test before buying such animals Unbred heifers and bull calves may be brought in with less risk but it is a wise precaution to have every animal tested Isolate pregnant cows until they have dropped their calves and have been tested after thirty days

If a blood test is made on the entire herd, dispose of all reactors at once to butcher If cows of unusual value are found to be reactors they may be isolated until after calving time Otherwise handle all cows as though infected if any abortion has occurred in the herd

Since aborting cows and infected cows are discharging the germs in large quantities at parturition, it is essential that they be isolated This is best accomplished by keeping them in individual maternity stalls, preferably in a building separate from the main cow barn The stalls should be isolated from one another Aborters and infected cows should be kept isolated until all discharges from the vagina have ceased These cows should be bred to a bull not used in the regular herd Artificial insemination is also desirable where abortion is a serious problem in the herd The maternity stall should always be thoroughly cleaned and disinfected when one cow is removed and another installed

When an abortion occurs, the animal should be treated by a competent veterinarian to avoid development of complications which may result in permanent sterility

The principal avenue of infection is through the mouth, and to avoid the spread of the disease, all feed and bedding should be handled so as to prevent contamination by the discharges from diseased cows, newborn calves, or milk from infected cows All bedding from maternity stalls, the afterbirth, the aborted calf, and all material containing discharges from aborting cows should be disposed of in

such a manner that none of the other animals will have access to it. If the abortion occurs in pasture, the ground should be covered with lime at the place where the calf was dropped and the aborted calf burned or buried where dogs may not drag it onto clean ground. A temporary fence around the spot is a good precaution.

Breed normal females only, and if there is any suspicion regarding the condition of the bull, breed on neutral ground and isolate the cow for a day or so after breeding to prevent spread of infection by mucus or seminal fluid which may drop from the vagina.

Keep close watch on the females in the herd for signs of abortion, which are quite similar to those in evidence at the time of normal calving.

Do not sell to others animals which have aborted. They should be sold only for slaughter.

Build up the resistance of the herd to all disease by feeding properly balanced rations containing a sufficient quality of essential vitamins and mineral elements.

Treatment by means of uterine douching should be undertaken only on the advice and under the direction of a veterinarian. Douches are of little value.

Douching the bull before and after service used to be a practice frequently recommended, but where care is taken to breed cows only after all discharges have ceased and their generative organs are normal, it would seem unnecessary to take this extra precaution. This matter is one on which the results of investigations are not in full accord.

Area testing. In recent years many states have started to control and eradicate contagious abortion by systematic testing of all cattle in county-wide areas by eradication methods similar to those used in tuberculosis control. Much progress is now being made; data from the U.S. Department of Agriculture show that in 1952 2,102,546 herds and 21,607,676 head of cattle were under supervision for Brucellosis control.

Udder Troubles. One of the most common troubles with dairy cows, especially highly developed milk producers, is inflammation of the udder. It varies in severity from a mild case, when the milk is

slightly stringy for a few days or a slight swelling is found in the udder, to severe cases, where the udder becomes so swollen that no milk can be drawn, and which may end with the permanent loss of one or more quarters of the udder

Congestion of the udder As a rule with heavy milkers, the udder is enlarged and more or less hot and tender just after calving This swelling may extend forward to some extent on the abdomen, but it is to be expected and need not cause any anxiety It is more pronounced when the animal has been well fed and is in good flesh When such a condition exists, the animal *should not* receive much grain until the udder softens The ration should be laxative in nature, and of a light character Bran is especially adapted for feeding at this time The milk should be drawn several times during the day, the udder actively rubbed or kneaded afterward Until the swelling leaves the udder, the cow should be kept from exposure to cold weather and to cold drafts, and off cold, wet floors

Inflammation of the udder This common trouble is also known as mammitis, or common garget It varies greatly in severity Many times the symptoms observed are swellings in the udder that *do not* even interfere with the milk secretion beyond causing a tenderness of the udder for a few days The milker should observe the condition of every cow carefully when milking, and report to the herdsman at once any abnormal condition noticed, or take any other action that seems necessary Prompt action is always advisable lest the conditions become severe Light attacks probably come from a variety of causes Any condition of the animal that lessens the power of resistance makes it possible for the trouble to start Such a condition of the animal may be brought about by exposure to severe weather, lying with the udder on a cold floor, injury to the udder by bruises, or improper or too heavy grain feeding In many cases, however, no special cause can be assigned Mild cases, as above described, usually respond to treatment if taken in time The grain ration should always be reduced at once to one third the usual amount or less when any inflammation appears, and kept there until the condition disappears A physic should also be given at once, and care taken not to expose

the cow to cold weather or cold drafts. An ounce of saltpeter per day for two or three days is generally beneficial after the purgative has begun to work. The cow should be isolated in a box stall and milked with great gentleness, and preferably three or four times per day. If the udder is extremely sensitive, a milking tube should be used for a few days. Hot fomentations applied from fifteen to thirty minutes three or four times a day usually bring relief. Specially constructed hot-water bags which fit the udder are on the market and are a great necessity in every good herd.

Infectious mastitis. This is an infectious disease of the udder and is not to be confused with the ordinary inflammation of the udder described above. It is caused chiefly by organisms of the streptococcus group. The *Streptococcus agalactiæ* is mainly responsible for the chronic form found in most herds, although the staphylococci are frequently the cause of some of the more serious or acute cases. Infectious mastitis is probably the worst disease, not excepting abortion, confronting dairymen today, with the least known about it or its practical control.

The first symptoms of the disease may be detected by the use of the strip cup. Small flaky particles may be observed on the fine mesh of the strip cup. From this simple first beginning, the disease may range through many forms, including the frequently observed acute form. The first symptoms of this form are a shivering of the animal, with cold ears and horns and loss of appetite followed in a short time by fever. One or more quarters of the udder swell and become very hard, which is most often the first noticeable symptom. The quarter or whole udder may be decidedly hot and tender, and no milk can be drawn. Frequently a small amount of yellowish watery fluid containing clots of casein replaces the milk. If the inflammation cannot be reduced in a short time, the quarter of the udder will not secrete any milk during the rest of the lactation period, and frequently remains a blind quarter. In some cases the quarter will again secrete milk in a reduced amount but can be diagnosed as an infected quarter by the presence of fibrous growths or hard spots in the quarter which may be detected by physical examination of the udder. In chronic cases

which may follow an acute attack, the quarter or udder may fill with pus which will finally be discharged either through the teat or through abscessed openings on the side of the udder

Infectious mastitis, or garget as it is sometimes called, is highly infectious and can therefore be readily transmitted from one animal to another through carlessness on the part of the milker or by allowing the milk from an infected cow to run or be stripped on the floor or gutters and later reach the udders of healthy cows Milking machines, unless carefully and properly handled, may be the means of rapid spread of this disease Any animal showing signs of mastitis should be immediately isolated and milked last to avoid spreading the disease to healthy cows by the milker

Numerous tests have been developed for detecting this disease The bromthymol blue and sediment tests and the actual isolation and identification of the types of udder organisms are the most accepted However, Rowland[1] and others have devoloped a promising new chemical analysis for detecting mastitis which may be applicable to subclinical cases It is based on the finding that the proportion of total nitrogen present in milk as casein is normally greater than 77 per cent, but less than this proportion in mastitis

In the past, numerous remedies or treatments have been tried and advocated More recently much more attention is being paid to careful milking practices and careful management and handling of the udder to avoid entrance of all infections to it A number of the newer types of udder infusions have been developed which are also proving of real value Such discoveries as penicillin, tyrothricin, gramicidin, Novoxil, silver oxide, phemerol, and sulfanilamide, and the new antibiotic aureomycin are being used with recoveries of up to 90 per cent being reported They must be used only by well trained and skilled herdsmen or veterinarians The milk should always be discarded for at least three days after these infusions or antibiotics have been used

It must be remembered that this disease is an infection of the most delicate organs and tissues of the body and in nonaccessible locations, and therefore treatment is limited and difficult At this time hope

[1] *Journal Dairy Research* 9 47 57 174–181 (1938)

seems to lie in the development of effective methods of sanitation and management to keep a herd free from this devastating disease as much as or more than in a cure after infection.

Teat Injuries. All dairymen are well aware of the role of udder and teat injuries in the mastitis problem of a dairy herd. Since infectious mastitis frequently is a sequel of these injuries to the udder or teat tissue and reduces the milk production of the affected cow, the aim of any treatment of the udder or teat injury is to bring about healing as quickly and as effectively as possible. Tyrothricin ointment when applied to chapped, sore, or cut teats has proved especially effective in quick healing and control of infections which may result in later mastitis trouble. All the rules for good sanitation should be observed in the control of mastitis.

Milk Fever. Until recent years the owner of high-producing cows always had to face the danger of losing the most valuable cows by this common and usually fatal disease.

Milk fever usually occurs only with high-producing cows. It rarely occurs with the first calf of a heifer, and seldom with the second. It affects mature cows, and especially the heaviest milkers. Milk fever is usually characterized by a drop in blood calcium and inorganic phosphate with an increase in magnesium. Milk fever has often been attributed to improper feeding. Cows in some areas of mineral deficiency or shortage seem especially prone to milk fever. The great advance made in recent years in the records of milk production of high-producing cows is to be attributed to a considerable extent to the new and effective treatments which reduce the loss from milk fever.

Symptoms of milk fever. The disease is so typical as to be easily recognized. It occurs in nearly every case within 48 hours after calving, and usually only after normal and easy parturition. Every cow likely to be affected should be watched carefully for symptoms until the danger is past. The first indications are restlessness and excitement on the part of the cow. Within a short time paralysis of the hind legs begins, resulting in a staggering gait. The animal soon falls and is unable to rise. From this time on the cow becomes unconscious, and remains so until death occurs in from 18 to 48 hours unless treated. The cow assumes a characteristic position, which is of great

value in diagnosing the case The head is turned to one side, and rests on the chest with the muzzle pointing toward the flank The entire body is paralyzed, making it impossible to give medicine, but fortunately none is required

The air treatment of milk fever The first effective treatment was discovered by Schmidt of Denmark, who injected a solution of iodine of potash into the udder Later Anderson, also of Denmark, found that the injection of ordinary air is far superior to the first treatment This was the method most commonly used by dairymen for many years and is still much used Every dairyman should be provided with a suitable milk fever outfit to treat cases as promptly as they appear The apparatus may be of various forms The most approved is shown in Fig 77 The essential parts are a milk tube, to which is attached a rubber tube, a receptacle of some kind in which clean cotton is placed to catch the dust in the air as it is pumped through it, and a rubber bulb or a pump of some kind In case an approved form of apparatus cannot be secured, an apparatus can be improvised that will serve the purpose

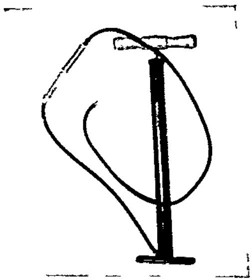

FIG. 77 Common apparatus for treating milk fever Consists of pump chamber carrying sterile cotton, sterile hose and teat tube

However, while it seems possible to stop the milk fever by any means that makes it possible to pump the udder full of air, there is great danger of introducing at the same time an infection that will cause inflammation and possibly result in the loss of the cow's udder

The calcium treatment Within the last few years considerable research work has been done on the cause of milk fever It has been definitely determined that its primary cause is a low calcium content of the blood This produces the main symptoms of the disease The

injection of calcium gluconate and other calcium salts directly into the jugular vein has been found to be very effective in restoring the blood calcium level to normal values. This is usually only done by a competent veterinarian, or skilled herdsman, and is rapidly becoming the standard treatment in large well-handled dairy herds. By this treatment recovery is rapid and no bad effects may result from udder infections common with the old-fashioned air treatment.

No attempt should be made to drench a cow suffering from milk fever, as her throat is paralyzed and any liquid introduced into the mouth will enter the lungs and cause pneumonia.

Lice. During the winter season especially, cattle are often affected with lice. Calves and young cattle are most often affected, but older cattle are not exempt, and when in an unthrifty condition they may suffer from this pest. There are two kinds of lice that affect cattle to any extent. The species generally known as the blue louse, which sucks the blood, and is the most common and most injurious, is found most numerous upon the neck and shoulders. The eggs are attached to the hair, and are known as nits The red louse, which is less common, may be found on any part of the body, but most numerous on the neck and at the root of the tail.

The presence of lice may be suspected from the cow's rubbing of the neck and shoulders on trees, posts, etc., and when the cow is badly infested the hair usually begins to come out in spots. Several substances may be used to kill the lice. The several coal tar dips and compounds on the market may be employed with success. Derris powder has more recently been coming into favor with dairymen as it is easy to apply, is not harmful to man or beast, and is very effective. The use of DDT, either as a dust or spray, is now becoming widespread. Care should be taken to follow carefully the directions for its use as advocated by the individual manufacturer, as it is prepared in many different forms for many different conditions. Methoxychlor and some of the new chlorinated hydrocarbon compounds are also proving very effective in lice control.

Pink Eye. This is a contagious inflammation of the eyes, common in many herds. It usually occurs during the latter part of the summer. It is known by a discharge from the eyes, accompanied by an intense

inflammation of the mucous membrane The eyelids swell, and the eye becomes opaque The eyes are kept shut, and the animal is often blind for several days In some cases the animal soon recovers without injury, while in others loss of the eyesight may result if proper treatment is not given

The affected animal should be kept in quarantine in a dark, cool stable and supplied with easily digested food and plenty of water The eyes should be washed at least twice daily with a saturated solution of boric acid (1 dram dissolved in 4 ounces of water) This wash should be applied directly to the eyeballs and can conveniently be done by the use of a syringe The animal will usually recover within a few days

Foot Rot This is the name applied to a common inflammation that occurs between the toes and may extend above the hoof It is attributed to infection from dirty and unsanitary barnyards getting into the irritation or cracks caused by stable manure, or by some foreign substance such as a stone or cinder, wedged between the toes It commonly affects sheep and cattle

Animals running in stony lots or pastures often become affected with foot rot It occurs, however, at times under conditions that leave no doubt that it is contagious It is recognized by a limping gait and a swelling above and between the claws The odor of the affected part is very offensive If neglected, a serious condition may develop, but if treatment is given during the early stages it is easily remedied The most simple method of treatment is to trim away all diseased tissue, cleanse the parts thoroughly, and then apply some good disinfectant to the affected parts This is best done by standing the cow in a box or pail containing a four per cent solution of copper sulphate It is well to bind the affected foot in a suitable bandage for several days to keep out dirt and further infection Very effective rubber boots are now available for this purpose

Infected cows should not be allowed to run in barnyards until completely recovered Animals not in milk may be treated by an application of suitable iodoform paste which usually requires only one application Because of its odor it must not be used on animals in milk or kept in the milking barn

Bloat. This trouble comes from the formation of an excessive amount of gas in the paunch. It often results from pasturing on wet or very young immature clover or alfalfa but may occur with any kind of feeding. It is indicated by the excessive swelling of the left flank. If relief is not obtained in time, the animal dies from suffocation caused by the great pressure on the lungs and heart. In mild cases driving the animal at a rapid gait for some distance may be sufficient.

The formalin treatment recommended by Healy and Nutter has given especially good results. This treatment consists in giving the affected cow a quart of a one and one-half per cent solution of formalin in the forms of a drench. A round stick is tied in the mouth to keep the jaws apart. One-half ounce of formalin in a quart of water gives a solution of the proper strength. Relief is sometimes secured by administering three to four ounces of kerosene in the form of a drench followed by the use of the wooden bit. Milk from cows so treated should not be saved for several days as it will have a pronounced flavor.

In very severe cases the gas must be removed without delay. This is best done by the use of a trocar. In using this instrument a spot is selected equally distant from the last rib, the hip-bone, and the backbone. The skin is cut for about an inch, then the trocar is thrust into the paunch. The sheath of the trocar is allowed to remain in the opening as long as any gas escapes, which may be several hours. It is generally advisable to give a dose of 1 to 1½ pounds of Epsom salts after a case of bloating. Danger from bloat can be largely reduced by feeding cows a good feed of dry roughage prior to turning hungry cows out on wet or immature pastures.

Impaction. Constipation or obstruction of the bowels is generally due to improper feeding. It is usually associated with all feverish conditions, and can ordinarily be prevented by avoiding excessive use of dry and bulky feeds, and by introducing more laxative and soft feeds in the ration. The condition of the feces is an early symptom of constipation, and the immediate administration of a physic when the feces appear unusually dry and in pellet form will ordinarily correct the condition. Impaction may be due to a twist or knot in the small

intestine, induced by unusually violent exercise or sudden movements In this case there appears to be no cure unless an incision into the abdomen is made and the knot or kink removed When constipation has gone unnoticed for some time, and the animal is in a feverish condition, warm injections into the rectum may help the action of the physic, but it would be well in such a case to consult a veterinarian Impaction is seldom encountered today in dairies using watering cups in the barn

Actinomycosis (Lumpy Jaw). This disease is characterized by a swelling on the lower jaw, which may finally open and discharge pus It is due to the growth of a fungus, which is introduced through injury to the mucous membranes lining the mouth, thus permitting the organism to attack the tissue If neglected, the swelling increases in size and the disease finally attacks the bone of the jaw If treatment is given in the early stages, while the disease is confined to the soft tissues, complete recovery usually follows the opening of the tumors, removal of the diseased tissues, and treatment with blue vitriol or iodine solution This treatment is best undertaken only by a competent veterinarian as this disease is communicable to man and all sanitary precautions must be taken Thorough cleaning and disinfection of stalls and equipment should follow the case of every infected animal

Cowpox. This disease is usually ushered in by a slight fever, and is easily communicated by the hands of the milker from cow to cow It attacks the udder and teats, and is characterized by eruption which are small at first, but increase in size and finally form into blisters with raised margins and a depression in the center If unbroken, these blisters finally dry up and drop off as scabs Cowpox ordinarily spreads to all members of the milking herd, but frequent washings with hyposulphate of soda solution may help to prevent the spread and check the inflammation

Ketosis or Acetonemia This is a nutritional disorder It usually occurs within a few weeks after calving and with cows that have been fitted for heavy production or that are in excellent condition It is also especially common in early spring after cows have had a long winter feeding of roughage and are changed to pasture The first

noticed symptoms are usually loss of appetite, loss of weight, and loss of milk flow. A check upon the ketones in the urine by a competent veterinarian should be made in all suspected cases although the test may not be too completely reliable.

The disease is often associated with milk fever and intravenous injections of calcium gluconate are often used. A change to feeds with a higher sugar content, such as the addition of molasses or corn sugar, and the use of highly palatable feeds usually brings satisfactory recovery.

Trichomoniosis. This is one of the newer and less commonly known diseases of American cattle. It was first reported by Emerson[2] in 1932, in herds in the eastern part of the United States. It has since been reported in many sections although as yet in a limited number of cases. It is apparently being spread very fast by the exchange of cattle, especially bulls. Because of its recent introduction to the United States and its newness even in Europe there is very little reliable information available about the disease or its control. Trichomoniosis appears to be a protozoan infection of a venereal character and may produce early abortion, pyrometra, and temporary sterility in an animal. The organism is flagellated and has been named by Cameron[3] and others as *Trichomoniosis-fœtus.* It is surprisingly resistant to heat and external physical and chemical influences.

It was at first thought that the bull was the main source of spread. This, however, now seems less certain, as virgin heifers have been found to be infected, indicating possible intestinal or other sources of infection. In the bull the disease seems only to irritate the sheath, causing him to be hesitant at mating time. An old bull, slow or lazy in service, may be suspected of being infected. In cows, infection may be suspected by irregular estrus or repeated breeding but failing to conceive. Also, pyrometral conditions may be evident.

There is no definite cure. Suspected animals should be examined by a competent veterinarian. Laboratory tests should be made to determine the organism. Suspension of all breeding for six or eight weeks of all infected females and the disposal of any infected bull

[2] Emerson, University of Pennsylvania Bulletin 59 (1935).
[3] Cameron, *Cornell Veterinarian*, Vol 25, No 2 (1935).

are recommended In addition to delayed breeding, the use of artificial insemination is highly recommended in all affected herds

Vibrio Foetus This is a type of abortion caused by the vibrio foetus organism It may strike a herd at any time, and often causes great confusion with any regular abortion control and eradication program It may run through a herd, infecting all females of breeding age It usually causes abortion during the first five or six months after conception and many cows following such an abortion remain nonbreeders or difficult breeders

Bulls are often the main carriers or source of original infection in a herd

This infection may be detected by a blood test, and blood testing for vibrio foetus of all valuable bulls and females is a wise precaution before addition to a valuable herd

Where a herd is known to be infected every measure thus far developed of isolation, cleanliness, sanitation, and blood testing under the supervision of a competent veterinarian of all infected cows at the time of heat, with the use of some of the newer antibiotics such as streptomycin, should be taken

Anaplasmosis This blood disease, while found in many parts of the world is most common in the southern and southwestern states The disease has been on the increase in the last few years While considerable research is under way as to its cause, nature of spread, and methods of control, as yet all too little is known about its detection, control, and eradication It is known that it is caused by a blood parasite called *Anaplasma marginale* and is probably spread from diseased to healthy cattle by ticks and other blood-sucking insects Its obvious symptoms are that animals show increased or difficult breathing, loss of appetite, evidences of anemia about the eyes, nose, and tail head, and milking cows have a rapid decrease in milk production Many severe cases die and others take many months to recover Treatment with some of the newer drugs such as aureomycin, pauldrine, and terramycin have been most effective Where this disease is suspected a competent veterinarian should be called

Leptospirosis This is a new disease in dairy cattle but is also

found in sheep and swine. It has been reported from many parts of the world. It is caused by a microorganism much larger than the Cattle Brucellosis bacterium. It is spread by contaminated feed and bedding and also by drinking water that has become contaminated by urine.

This disease is recognized by high temperatures, reduced appetite, loss of weight, and difficult breathing; also by loss in milk production and abnormal character of milk.

Up to 90 per cent of a herd may become infected with a high death rate in young stock. Losses also occur by abortion, sterility, low carcass value, and stunting of young stock.

Blood tests so far seem to be the best means of diagnosis. When found, all suspected animals should be isolated or disposed of and a program of complete sanitation and clean-up seems to be the most effective control to date.

Hardware Disease. With the greater mechanization of the farm and the handling of cattle, large numbers are being lost each year through the taking into the digestive system of nails, bits of bailing wire, broken metal parts of tools, and other foreign bodies that cause injury and death. Because the cow does not fully chew her food before swallowing, these foreign bodies pass on into the digestive system and usually lodge in the reticulum. If sharp they may be pressed through this part of the stomach and enter the heart or other vital organs where abscesses may form and death eventually results. A study of a number of dairy herds by one of the experiment stations[4] has shown that wire and nails and other foreign bodies caused the death or disposal of 5.3 per cent of all bulls in natural service and 3.0 per cent of bulls used in artificial service. The loss of cows was correspondingly high.

Every effort must be made at all times to keep such material out of the feed supply. The use of magnets in feed mixers and feed chutes is very helpful in the reduction of this troublesome new problem of modern dairy farmers.

[4] Florida Experiment Station Bulletin 540 (1954)

CHAPTER XXV

Digestion in the Ruminant*

The Digestive Systems of Domestic Animals All farm animals may be divided into two different groups, depending on the nature of their digestive systems They are the ruminant group and the nonruminant or monogastric group Differences in feeding practices between kinds of farm animals depend upon the structure and functions of the digestive system and particularly the stomach A full understanding of these differences is fundamental to all successful feeding practices as well as to good farm management The character of the feed supply, its availability, and its ease of production as a part of the farm program all play a part in the type of animals selected that can best consume such feeds

The ruminant stomach is adapted to utilize leafy forages This function serves either extensive or intensive agriculture, since ruminants use efficiently the leaf and stem portions of many crops that are of little value to man, poultry, or swine Ruminants convert these forages into body tissues, milk, and other products

Ruminants and nonruminants are alike in that the stomach is sterile at birth, microorganisms gaining entrance from the postnatal environment Digestive enzymes are produced in glands accessory to the digestive tract The saliva of cattle contains no enzymes The rumen, reticulum, and omasum are also nonsecretory Gastric juice functions in the abomasum, bile and pancreatic and intestinal juices in the small intestines No known enzyme secreted by the animal attacks cellulose, which forms the walls of plant cells Nature pro-

* Author Dr R. B Becker Professor of Dairy Husbandry University of Florida 1955

vides means whereby cellulose may be partly broken down early during the passage of feeds through the digestive tracts of ruminants.

THE COW'S STOMACH

General Description. *The cow's stomach has four main parts:* rumen, reticulum, omasum, and abomasum commonly called the paunch, honeycomb, manyplies, and true stomach, respectively. The inside structure of these compartments is shown in Fig. 78. The stomach and its compartments are visible during the early stages of fetal development.[1,2] At birth, the omasum and reticulum are least developed. At that time the abomasum has nearly the capacity of the other three compartments combined, while the rumen is second to it in size. Blades of grass have been found in the rumen of a calf slaughtered when under one day old, and fine feed particles have been found between the laminae of the omasum in calves seven to thirteen days old. Within twenty days, all stomach compartments are functioning in the digestion of common feeds.

The stomachs of mature cows vary in capacity from 25 to 60 gallons (150 to 300 pounds) depending on the size of the animal. At maturity, the rumen has about 80 per cent of the total stomach capacity; the reticulum about 5 per cent; the omasum and the abomasum each have about 7 to 8 per cent. The size varies greatly with individuals and with feeding practices.

Rumen. The rumen is located largely in the left side of the abdominal cavity. It increases rapidly in size as the calf grows and begins to eat forage. The rumen wall contains muscle fibers that aid in the rotary motion of food in the stomach. Sturdy muscular pillars divide the rumen into dorsal, ventral, and two posterior sacs. Much of the inner wall of the rumen is lined with numerous large papillae, giving the organ great absorptive area.

The esophagus starts at the mouth, passes down the throat, through the chest cavity and diaphragm, and enters the rumen at the cardia, high on its anterior wall. The esophageal groove begins at the end of

[1] Winters, Green, and Comstock. *Prenatal Development of the Bovine.* Minnesota Agricultural Experiment Station Technical Bulletin 151:3–50 (1942).

[2] Becker, Dix Arnold, and Marshall "Development of the bovine stomach during fetal life." *Journal Dairy Science*, 34:329–332 (1951).

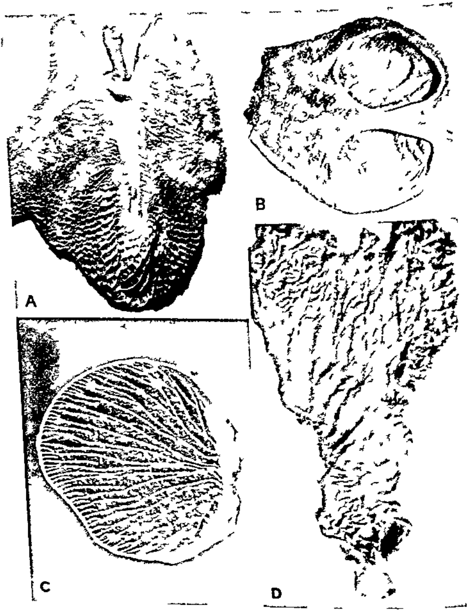

FIG. 78 Interior of the cow's stomach *A* The rumen wall divided to show entrance of the esophagus at the cardia and the esophageal groove (stretched open) along the reticulum wall to the reticulo-omasal orifice Papillae line the rumen wall The reticulum has a honeycomb-like structure *B* Posterior lobes of the rumen, and muscular pillars *C* Five orders of laminae extend from the outer curvature more or less toward the median short curvature (sulcus omasi) *D* Twelve spirals of the mucous lining in the cardiac portion terminate at the constricted middle of the abomasum A prominent circular muscle controls the pyloric valve between the abomasum and the small intestine (Courtesy Florida Agricultural Experiment Station.)

the esophagus in the rumen, and continues as part of the rumen wall, somewhat downward along the reticulum wall, to the omasum. The lips of the esophageal groove of calves, when nursing, react to close partly and thus it conveys the trickle of milk directly to the omasum,[3,4] where it passes downward to the abomasum. Milk in large swallows may pass into the rumen, where it may putrefy, which may cause scours. The use of a nipple bucket will allow the calf to take milk slowly, which promotes proper passage into the abomasum. Coarse feeds, grain, most of the water, and saliva pass into the rumen.

Reticulum. The reticulum is attached to the forward part of the rumen. The mucous lining of the reticulum forms a honeycomb-like structure which often collects small heavy foreign objects. Since this organ is in contact with the diaphragm and the liver, sharp metal objects that puncture its wall may pierce the diaphragm and injure the heart, or may produce abscesses of the liver, causing either sudden death or chronic illness. This condition has been called "hardware disease." On the other hand, metallic objects may remain harmlessly in the honeycomb structure until wholly dissolved by weak organic acids produced during rumen digestion. The mucous linings of the stomach have absorptive powers.

Omasum. The omasum is located on the right side of the abdomen, near the junction of the rumen and the reticulum. The outer curvature lies against the right abdominal wall. It connects through a short neck on the upper median side with the reticulum. It empties into the abomasum through a large orifice on the lower median side. The omasum lies largely above the anterior end of the abomasum.

Laminae or leaves of five widths are inserted longitudinally on the inner wall of the greater curvature and also on the sides of the omasum. The free borders of each lamina extend more or less toward the medial wall or sulcus omasi, as shown in Fig. 78. The sulcus omasi or free passageway extends mainly downward along the

[3] Amadon, *The ox stomach. Some facts which cattle owners should know.* North Dakota Agricultural Experiment Station Bulletin 196:1–16 (1926).

[4] Schalk and Amadon, *Physiology of the ruminant stomach (bovine). Studies of the dynamic factors.* North Dakota Agricultural Experiment Station Bulletin 216:3–64 (1928)

interior face of the lesser curvature, providing an almost free passageway for liquids and fine feed between the inlet and outlet Surfaces of the laminae are studded with numerous papillae arranged more or less in rows toward the outer curvature The laminae vary in length and the points of upper and lower insertion occasionally terminate on the side of another larger lamina Several horny papillae are at the upper ends of some of the largest laminae Their tips curve inward toward the omasal cavity Papillae are smaller and more numerous toward the lower end of the laminae The anterior ends of the large primary laminae partly fill the reticulo-omasal orifice, allowing mainly only liquids, small feed particles, and some grains to enter the omasum The mucous lining of the omasum also is an absorptive area

Abomasum The fourth compartment is the true stomach It is the only stomach tissue, the mucous lining of which contains glands that produce digestive juices The "chief" cells in the anterior or fundic portion produce hydrochloric acid About twelve spiral folds of the mucous lining extend into the abomasal cavity in the fundic region The folds terminate toward the more constricted middle of the organ The posterior or pyloric portion has both chief and parietal cells, producing both hydrochloric acid and the gastric juice The abomasum is separated from the small intestine by the pyloric valve, guarded by a well-developed sphincter muscle This valve opens at intervals, permitting some of the contents to pass into the duodenum or anterior portion of the small intestine The gastric juice contains the enzymes rennin, pepsin and also a small amount of gastric lipase These enzymes act on casein, other proteins, and some fine fat particles

Portions of each stomach compartment are shown in Fig 78

GROWTH AND DEVELOPMENT

As the animal grows older, the stomach tissues grow in size, thickness, capacity, and weight The net weights indicate the relative growth of the different compartments[5] The proportions of the dif-

[5] Becker and Dix Arnold *Early development and function of the bovine stomach* Assoc of So Agrl. Workers Proc 49 78 (1952)

ferent tissues on the empty basis are given in percentages of total weight, as follows:

AGE	NUMBER OF ANIMALS	RUMEN	RETICULUM	OMASUM	ABOMASUM	TOTAL STOMACH
		%	%	%	%	%
At birth	5	33.8	7.3	12.8	46.1	100.0
63–67 days	3	48 6	9 3	13 1	29.0	100.0
238 days	1	54 0	8 0	22 0	16.0	100 0
5–10 years	24	46 5	10.0	30 0	13.5	100 0

STOMACH MOVEMENTS

Studies of the Stomach. A stomach fistula was first used to study digestion in man. Alexis Saint-Martin was accidentally shot in the stomach in 1822, and the wound never healed shut. Dr. Beaumont collected gastric juice and studied digestion of various foods with the co-operation of Saint-Martin, publishing his observations in 1833. Rumen fistulas were first used by G. Colin[6] before 1900, and later by A. F. Schalk and R. S. Amadon and others since 1921. For direct observations of stomach functions in cattle, successful use of the fistula required efficient methods of closure to exclude air when not under observation.

The food is passed through the digestive tract by peristalsis, concerning which Schalk and Amadon stated: "The cycle of motility originates within the reticulum. Two rapid contractions are executed by the walls of this cavity; the second movement following the first without intervention of an appreciable time interval. The first reticular contraction forces a flow of reticular liquids upward and backward flooding the cardia region and continuing posteriorly to the various portions of the rumen. The second reticular contraction follows the first immediately and is usually the more powerful of the two movements." A complete peristaltic wave of the rumen requires about one minute to complete, and aids in the rotary movements of contents.

Some 100 to 125 pounds of saliva are secreted daily by the mature

[6] Colin, Traité de physiologie comparée des animaux. Troisième édition, tome premier, Chap 24, page 685. Paris (1888).

cow Saliva and water provide liquid to soak hard feeds and facilitate growth and activity of microorganisms They assist in transporting feed materials from one part of the rumino-reticular cavity to another, to other parts of the stomach, and enable regurgitation of feed for rumination

The rhythmic contractions of the omasum are slow and deliberate Differences in the contraction patterns of parts of the cow's stomach are shown by kymograph tracings (Fig 79) obtained by A F

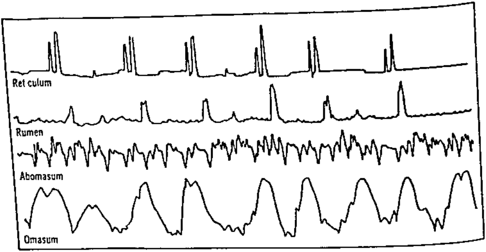

FIG 79 Kymograph tracings of pressures taken simultaneously in four compartments of the cow's stomach These show the peristaltic contractions which aid in movement and maceration of feed in the stomach (Taken from North Dakota Agricultural Experiment Station Bulletin 216)

Schalk and R S Amadon [4] with aid of a rumen fistula Feed appears to gain entrance by an aspiratory action at about thirty second intervals and perhaps to move onward during contractions Fluids pass downward into the abomasum, while feed particles enter between the laminae because of their slightly pedunculated shape at the neck They continue downward assisted by the alternate relaxation and contraction within the organ

FUNCTIONS OF THE RUMINANT STOMACH

Feeding Habits of Cows The cow divides the day into three nearly equal intervals eight hours to graze or eat, eight hours in

rumination, and eight hours of rest.[7,8] Rumination is distributed throughout the twenty-four-hour period. The exact times vary with kind and availability of feeds and management of the animals. Shorter periods are used in feeding and rumination when feeds are obtainable readily. Nine cattle at the North Dakota station spent 6.4 hours eating, 6.4 hours ruminating, and 11.2 hours at rest.

Mastication. Feeds are chewed briefly, lubricated with saliva, and swallowed. They enter the anterior part of the rumen. Frequent periodic waves of contraction initiate in the reticulum wall, passing on to the rumen. This peristaltic action gives a slow rotary motion and also tends to macerate feeds. Liquid from the reticulum assists the lighter feeds to pass along the upper portion of the rumen, backward, then downward and forward along the floor. There is more moisture in the lower part of the rumen and reticulum. Generally, the feed is ready for rumination in about twelve to twenty-four hours after feeding.

A cow drinks water and secretes 100 to 125 pounds of saliva daily. In addition, many feeds contain a large amount of water. With this liquid she soaks and softens the feeds for maceration and for attack by rumen microorganisms.

Rumination. Rumination takes about one third of each day. Calves often ruminate when only two weeks old. In rumination a bolus of moist feed and liquid is brought up the esophagus by the suction created and a wave of reverse peristalsis. This is brought about by a closure of the glottis, the lifting of the ribs, tightening of the diaphragm, and contraction of the reticulum and rumen, which cause coarse feed and liquid to be brought against the cardia at the then dilated end of the esophagus. The liquid is swallowed immediately. The regurgitated feed or cud is chewed some twenty to fifty times, depending on its succulence or fibrous character. It is then swallowed and the process is repeated as often as necessary. Friction and pressure of coarse feed against the anterior wall of the reticulum stimulate rumination.

[7] Fuller, *Some physical and physiological activities of dairy cows.* New Hampshire Agricultural Experiment Station Technical Bulletin 35:3–29 (1928).

[8] Fisher, Grof, Hardison and Thompson, "The grazing behavior of lactating cows on pasture," *Journal Dairy Science,* 37 665–666 (1954).

MICROBIOLOGICAL ACTIVITY

Importance The importance of microorganisms as a part of rumen digestion has been fully recognized recently Although bovine stomachs are biologically sterile at birth,[9,10] four groups of microorganisms gain entrance and are present in older cattle These are aerobic and anaerobic bacteria, protozoa, and yeasts Aerobic bacteria and yeasts gain entrance incidentally in the feed and water, and perhaps other ways Many species of aerobic bacteria have been identified which may or may not be beneficial or harmful Mainly, these species are not regarded as having essential beneficial functions They are digested later in the abomasum and small intestines The useful anaerobic bacteria and protozoa are obtained through contaminated feed, water, cud inoculation, or by the cow licking her calf

The normal rumen bacteria and protozoa aid by attacking plant cells with cellulose-splitting and other enzymes Protozoa ingest many bacteria as well as some feed nutrients, and contribute to the breakdown of feed particles In this process they produce much acetic acid, some propionic acid, a little butyric acid,[11] besides methane and other gases,[12] and also give off heat The rupture of the cellulose cell walls exposes the contents to digestion later The organic acids are absorbed as their sodium salts largely from the rumen, reticulum, and omasum The gases are mostly eliminated by belching and during rumination

Anaerobic bacteria use ammonia, urea, and other nonprotein nitrogen compounds as well as the proteins in feeds, converting them into plant proteins in their cells Bacteria multiply rapidly after the cows eats, reaching maximum numbers around six to ten hours after a meal Protozoa multiply more slowly, and reach peak numbers ten to twelve hours after a meal, about which time the numbers of

[9] Butner "A comparison of the aerobic microflora in the stomach of calves." University of Florida. M.S thesis, 53 pages (1947)

[10] Uzzell, Becker and Jones "Occurrence of protozoa in the bovine stomach," *Journal Dairy Science* 32 806–811 (1949)

[11] Bancroft, McAnally and Phillipson, "Absorption of volatile acids from the alimentary tract of the sheep and other animals." *Journal Experimental Biology* 20 120–129 (1944)

[12] Hastings, "Significance of the bacteria and protozoa of the rumen of the bovine" *Bacteriological Review* 8 235–254 (1944)

bacteria decrease. Loosli[13] observed that these organisms produced all ten of the essential amino acids: arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophane, and valine when the proper precursors were available. These protozoa ingest bacteria and feed particles, converting nitrogen compounds into animal proteins of their bodies.

Rumen bacteria have been found to synthesize water-soluble vitamins[14] by a rumen fistula made in the side of the Holstein-Friesian cow Penstate Homestead Jessie. Observations by many investigators disclosed synthesis of biotin, of folic, nicotinic, and pantothenic acids, pyridoxine, riboflavin, thiamine, and vitamin B^{12} in the rumen. The fat-soluble vitamins, except vitamin K, do not appear to be synthesized in the digestive tract, but must be obtained solely from feeds.

Gases. Methane, carbon dioxide, and other gases are formed during rumen digestion. Some are absorbed and eliminated through the blood and by respiration. However, most of the gases are eliminated by belching and at time of rumination. If these gases accumulate faster than they can be eliminated, the animal will bloat. Acute bloat may result in death if not relieved quickly. Chronic bloat requires attention, but is less serious.

Heat is given off during the digestion of feeds by microorganisms in the rumen and reticulum. This is one source of body warmth in cold weather, but must be dispersed in warm weather through radiation from the body surfaces, increased respiration, and evaporation of water from the lungs and skin.

Rumen digestion in cattle is practically completed in about twelve hours after a meal.[15]

DIGESTION IN THE OMASUM

Mainly liquids, fine feed particles, and small seeds gain entrance into the omasum. The liquids drain quickly downward along the

[13] Loosli, Williams, Thomas, Ferris, and Maynard, "Synthesis of amino acids in the stomach." *Science*, 110:144–145 (1949).

[14] Bechdel, Honeywell, Dutcher, and Knutsen, "Synthesis of vitamin B in the rumen of the cow." *Journal Biological Chemistry*, 80:231–238 (1928).

[15] Hale, Duncan, Huffman, "Rumen digestion studies. II. Studies in the chemistry of rumen digestion." *Journal Nutrition*, 34:747–758 (1947).

short medium wall into the abomasum The softened feed particles pass between the laminae filling the organ, and move gradually downward and out the lower orifice into the abomasum Some reduction in size of feed particles occurs during this passage in dairy cattle [16] When the omasum was by-passed surgically (in young goats),[17] feed particles in the abomasums were much coarser than in normal goats eating the same feed Schalk and Amadon[4] observed rhythmic contractions of the omasum, associated with movement of feed downward between the laminae of the omasum Hard seeds and whole grains are not reduced

The sodium salts of acetic, propionic, and butyric acids are absorbed principally from the rumen and reticulum Small amounts are absorbed from the omasum, but little from the abomasum

Following mechanical and biological phases of digestion and synthesis described previously, the food nutrients are ready to undergo a type of digestion similar to that in single-stomach animals Hydrochloric acid is produced there, and puts many minerals in solution It also activates the pre-form of the protein-splitting enzyme (pepsin) secreted in the gastric juice Another enzyme, rennin, splits the casein into paracasein and makes it ready for further hydrolysis by pepsin Gastric lipase also begins the hydrolytic action of fats, but not to any great extent

DIGESTION IN THE ABOMASUM

The greater efficiency of ruminants to handle feeds efficiently is due to the mechanical and biological preparation which they are able to give to all feeds consumed before the final digestion common to other single-stomach animals starts

Intestinal Digestion As the food nutrients pass onward into the intestinal tract, they meet the bile and pancreatic and intestinal juices with their respective salts and enzymes The bile tends to emulsify fats into smaller globules, giving greater surface area for enzyme

[16] Becker "Certain points in the physiological processes of the cow I The omasum as a grinding organ." *Journal Dairy Science* 20 408–410 (1937)
[17] Trautman and Schmitt, The function of the omasum Deutsch Tierartzl Wochenschr 43(12) 177–179 (1936)

activity by the pancreatic lipase which splits fats into fatty acids and glycerol. Bile salts convert the fatty acids to neutral soaps.

Proteins and their by-products are digested further into amino acids by trypsin and erepsin from the pancreatic and intestinal juices. Starches are hydrolized to maltose by intestinal amylase. The common double sugars—maltose lactose, and sucrose—are broken into simple sugars by the invert enzymes.

Absorption. Although absorption of the smaller soluble food nutrients occurs all along the digestive tract, it is most active in the lower part of the small and in the large intestines. The neutral soaps and glycerol are absorbed and reconverted to neutral fats and carried as such by the lymph directly into a large vein near the heart. The blood takes up the simple sugars, amino acids, minerals, vitamins, water, and some other substances. These pass through the portal circulation of the liver before going to the heart, and on to the lungs and body generally.

The description of digestion in ruminants clarifies their relative independence of so-called "protein quality" in rations, and of major feed sources of water-soluble vitamins. It also explains ability of ruminants to utilize some nonprotein nitrogen compounds in feeds. They consume and utilize a large proportion of leafy roughages to advantage, and produce considerable heat during the digestive processes. For feeding yearlings or older cattle, however, it is usually economical to crush, roll, or coarsely grind grains and hard seeds for their efficient utilization. Calves consume smaller amounts of feed daily and masticate grains deliberately at first chewing.

CHAPTER XXVI

Feeding for Milk Production

The economical production of milk depends largely upon two general factors The first is the efficiency of the cow used The efficient cow is the result of inheritance, and an animal with the desired characteristics is to be obtained by selection and breeding The second factor controlling milk production is feed and care Proper attention to the selection of the individual animal and to breeding merely insures that an efficient machine will be available for milk production.

Feed the Limiting Factor The inherited ability of the cow to produce milk and the skill with which she is fed and managed contribute about equally to the final result Where dairy cows are kept under approved conditions, about half the total expense is for feed the remainder represents labor, depreciation, housing, interest, and other miscellaneous items The labor and other items mentioned are practically the same regardless of the total milk production It takes nearly as much work to care for a cow giving 4,000 pounds of milk as it does for one producing 8,000 pounds These expenses outside of feed, generally called *overhead expense,* represent about half the cost of producing milk A farmer with cows has to meet these overhead expenses, and so should make certain that his cows have the proper feed to enable the full use of their producing ability

It is known that insufficient and improper feeding limits the milk production of probably the majority of dairy cows The average milk production in the better developed dairy states is above 6 000 pounds annually These same cows with better feed could easily average

from 6,500 to 7,000 pounds of milk or 235 to 275 pounds of fat. The Iowa Experiment Station some years ago purchased for experimental purposes a group of cows from the Ozark region as best representing the scrub or unimproved stock. Yet these cows when given good care and feed averaged 187 pounds of fat, which was more then than the average of the United States. The University of Minnesota some years ago purchased a group of cows of unknown breeding to be used in a breeding-up demonstration by means of a purebred sire. Yet these cows averaged 196 pounds of fat when given a good ration. These examples show the importance of feeding and the possibilities of improvement, especially under conditions average or below.

PASTURE

Turning Cows on Pasture in the Spring. Every owner of a cow welcomes the time when the animal can be turned out to pasture. The extra labor and expense connected with winter feeding are reduced. Experience shows that usually the herd may give the best results of the year during the first two months on good pasture. However, young grasses are high in water, often containing not over 10 per cent of dry matter or less than milk itself. Seldom can a heavy-milking cow eat enough of such succulent pasture to supply the necessary nutrients. Gradually changing from dry feeds to pastures may avoid characteristic feed flavors from this source.

A common mistake is to pasture too closely in the fall and too early in the spring. Grass grows from nutrients built by the leaves in contact with air and sunshine above the ground. If grass is kept too short, its growth is retarded. On the other hand, digestibility of the dry matter of grasses becomes lower as they mature.

Grain Feeding on Pasture. There is some difference of opinion on this question, from the standpoint of economy. There is no question that a cow will produce more milk if fed grain while on pasture; and if a large yield is of more importance than economy of production, grain should certainly be fed. The cow that gives a small average quantity will produce but little more if fed grain while on pasture. However, it is necessary that a heavy-producing

cow be fed some grain to continue long on the high level of production. A high producing cow cannot secure sufficient nutrients from grass alone. She must have some concentrated feed from which to produce a large quantity of milk.

A cow producing 35 pounds of average milk daily requires about 30 pounds of dry matter in her feed. Fresh pasture grass contains not over 25 pounds of dry matter to the hundred. A cow producing the very moderate yield of 35 pounds of milk daily would require close to 150 pounds of grass.

The physical exertion necessary merely to gather this amount of grass, to masticate and digest it, is clearly a hard day's work. While it is possible on good pasture for a cow to gather and digest sufficient feed for this yield of milk, too often the grass is short and it is impossible for the animal to gather the required food. With higher-producing animals the conditions are still more difficult.

Experiments by Roberts and Wing[1] covering four years showed that, while an increase in milk yield was secured from grain feeding, it was not economical under their prices to produce it in this way. In these tests, about an additional pound of milk was secured for each pound of grain fed. In these experiments the pastures produced an abundance of nutritious grasses, and the average production was not high. It was observed, however, that the cows fed grain during the summer gave better results after the grazing period was over than those not receiving grain. This is also a matter of common observation, and should be taken into account in considering the advisability of feeding grain. The cows which were fed grain stored surplus nutrients, which were afterwards available for the production of milk.

A compilation from reports of cow testing associations in Minnesota showed the following:

	PASTURE ONLY	GRAIN AND PASTURE
Number cows	700	300
Average fat yield	238	302
Cost of feed	$41.87	$49.35

[1] Cornell University Agricultural Experiment Station Bulletins 13, 22, 36, 49 (1887-1892).

These figures indicate that by feeding grain then worth $7.28, an additional 64 pounds of fat were secured during the year which was worth $24.71 at 40 cents per pound.

When to feed grain. The condition of the animal and the amount of milk produced should determine how much grain, if any, should be fed while on pasture. No cow can produce a large amount of milk for any length of time on grass alone. A cow producing a pound of fat or more a day is in the class where it pays to feed grain. This would include a Jersey or Guernsey producing twenty pounds or more and a Holstein, Brown Swiss, or Ayrshire giving above twenty-five pounds.

The following recommendations have been found to be satisfactory for the different breeds:

Jersey or Guernsey cow producing:

20 lbs. milk daily	3 lbs. grain
25 lbs. milk daily	4 lbs. grain
30 lbs. milk daily	5½ lbs. grain
35 lbs. milk daily	7 lbs. grain
40 lbs. milk daily	8 lbs. grain

Holstein, Shorthorn, Brown Swiss, or Ayrshire producing:

25 lbs. milk daily	3 lbs. grain
30 lbs. milk daily	4 lbs. grain
35 lbs. milk daily	5½ lbs. grain
40 lbs. milk daily	7 lbs. grain
50 lbs. milk daily	9 lbs. grain

It must be kept in mind that this applies only when pastures are abundant. Where a small amount of grain is fed to a cow on pasture, any farm grain such as corn, oats, or barley serves the purpose. The grass supplies a liberal amount of protein and little attention is necessary to the protein content of the feed.

When liberal grain feeding is necessary—for example, five pounds or more daily—some attention should be given to the grain ration used that it contain more protein and have variety and palatability. In fact, the same mixture as that used as dry and fitting feed can be used with advantage.

Providing for Periods of Short Pasture Mixed plantings of improved fertilized pasture crops and temporary pastures extend the grazing season As long as fresh pasture grasses are abundant, the ordinary cow is about as well provided as she can be to produce milk economically Unfortunately the season of abundant pasturage is often short In many localities dry weather, often for several weeks, occurs at some period during the summer, and the pastures become short and insufficient to maintain a full flow of milk This season is often the critical time of the year for the dairy cow It is probable that as much loss occurs because of lack of feed at this time as occurs from improper feeding during the winter season When the season of dry feeding arrives, the farmer expects to feed his stock, and is prepared for it On the other hand, as long as the cattle are on pasture and the field work is pressing, the tendency is to let the cows get along the best way they can

On many farms, the cows are fresh in the spring and give a good flow of milk while the pastures are good, but when hot weather, flies, and short pastures come, the flow drops one half or two thirds, and the cows produce but a small amount in the winter when the price is the highest It is almost impossible to restore the flow of milk to the original amount after it is once allowed to run down from a lack of feed To make large returns per cow a large yearly production must be had, and to do this, the flow of milk must be kept up for ten or eleven months in the year It is the nature of bluegrass—a widely used pasture grass—to grow freely in the early summer, then to rest until fall This leaves a period in midsummer, where bluegrass is depended upon for pasture, when the pasture is apt to be short Other grasses also have characteristic growth habits

SILAGE AND SOILING

The Relative Economy of Silage and Soiling Crops for Summer Feeding It is possible to maintain the milk flow by heavy grain feeding but this is unnecessarily expensive Some succulent feed should always be on hand to supplement the pasture

The Wisconsin and Iowa Experiment Station found that silage and soiling crops are equally efficient as supplements to pastures Silage

can be grown more cheaply on most farms than soiling crops. It is evident that the labor expense will be less to raise a field of corn for silage than it is to plow, work, and plant a number of small plots of soiling crops and have them ready as supplementary feeds at different times throughout the growing season. The expense for seed is also decidedly less when corn is used than when a variety of soiling crops is grown. The most important advantage of silage is in connection with the harvesting. The harvesting of corn for the silo is done at one time, with the help of efficient machinery. The soiling crops, on the other hand, have to be cut in small lots daily with appropriate machines.

The difference between the yields of silage and soilage is not great. Silage has an advantage over soiling crops in that it is somewhat more mature when cut. The figures below show the average results for three years reported by the Wisconsin Experiment Station.

	YIELD PER ACRE	TOTAL DRY MATTER PER ACRE	CRUDE PROTEIN PER ACRE
	Tons	Lbs.	Lbs
Corn silage	15 0	8,850	810
Corn, soilage	13 3	6,633	585
Peas and oats, soilage	9 3	4,450	570

These figures show that corn yielded more total nutrients and protein than peas and oats used for soilage. A comparison with alfalfa, however, would be somewhat less favorable to corn silage. Alfalfa and other forage crops are adaptable for silage. First cutting of hay which is often difficult to cure can be put into the silo when the silo is usually empty after winter feeding.

Disadvantages of Corn Silage. A lack of variety is probably the greatest disadvantage of corn silage, especially when fed both winter and summer. Soiling usually includes several crops including some legumes which supply both protein and mineral matter in much larger quantities than corn. Where corn silage is fed, a liberal amount of protein must be supplied in concentrates or in legume hay. Another difficulty in feeding corn silage is that more than two inches must

be taken off the entire surface of the silo daily to prevent spoiling during warm weather

The Summer Silo In order to insure the keeping of silage it is necessary to have a silo of small diameter in relation to the size of the herd For summer feeding, a silo twelve feet in diameter is ample in size for thirty cows For this reason, when the herd does not exceed fifteen cows, the use of soiling crops is generally advisable Silage can be kept in good condition during the summer where only a few cows are being fed each day, if a canvas is spread over the surface of the fresh silage after each feeding If the silage in a summer silo is not needed, or only partially used at silo-filling time, any spoiled material on the surface should be removed and the new silage can be put in on the old without any danger of spoiling Good silage can be carried over from one year to another

Feeding Soiling Crops Soiling crops may be fed either in the pasture or in the barn In the pasture some waste results from tramping and fouling with manure Feeding in the barn requires more labor but saves feed, and the cows will do better if kept in the barn in the middle of the day and protected from flies Soiling crops are generally cut daily but may be kept over one day by piling in the shade Soiling crops are usually fed once a day when scattered on the pasture, and twice a day when fed in the barn From 40 to 70 pounds a day is the amount usually fed as a supplement to pasture When fed as the sole roughage, up to 100 pounds daily will be required for the mature animal

Winter Feeding and Maintaining Summer Conditions Throughout the Year Every owner of a dairy herd knows that normally his herd reaches the maximum production in early summer when the pasture grass is abundant and other conditions ideal

This suggests that the problem of the dairyman is to imitate these conditions of abundant pasture during the remainder of the year This is exactly what the careful dairyman and skilled feeder do, and results correspond closely to the success with which these conditions are maintained These conditions which bring the maximum production in early summer and which should be maintained the remainder of the year may be described as follows

1. An abundance of palatable feed.
2. Succulent feeds and water.
3. A sufficient supply of protein.
4. Moderate temperature and comfortable surroundings.

AMOUNT OF FEED

The first condition given as typical of the summer feeding is an abundance of palatable feed, and on this point is made one of the most common mistakes in feeding cows under conditions of dry feed. In producing milk, the cow may be looked upon as being in a way a milk-producing machine which we supply with a certain amount of raw material in the form of feed, and which manufactures this raw material into milk. The same rule holds as in the running of any other manufacturing plant; it is run most economically near its full capacity. Everyone who feeds animals should thoroughly comprehend that, first of all, the animal must use a certain proportion of its food to maintain the body. This is the first requirement of the animal, and it is usually the first use to which it puts its food. This is called the *ration of maintenance,* and it is practically a fixed charge. That is, it is practically the same whether the animal is being utilized for maximum production or is merely kept without producing any milk at all.

In the case of an ordinary dairy cow this ration of maintenance amounts to from 50 to 60 per cent of all she can consume. In the case of the heavier-producing animal—for example, one producing from 1 to 1¾ pounds of butterfat per day—this ration of maintenance amounts to from 40 to 50 per cent of the total feed of the animal. Clearly, after giving the animal the necessary amount to keep her alive, it is the poorest economy to refuse to furnish the other 40 to 60 per cent, which she would utilize exclusively for milk production. On the average farm this is one of the most common mistakes made. The importance of liberal feeding for economical production can be easily understood from Figure 80.

The first line illustrates the proper feeding of a heavy-producing cow, which is the one usually underfed. The line *a* to *c* represents the total capacity of the animal for food, or a full ration. The first half, from *a* to *b*, represents the amount of food required to maintain the

animal's body, or the ration of maintenance. The second half, that portion from b to c, represents the proportion of the food used for the production of milk. In this case there is no fat being produced on the animal's body, and the cow is supposed to be of such dairy

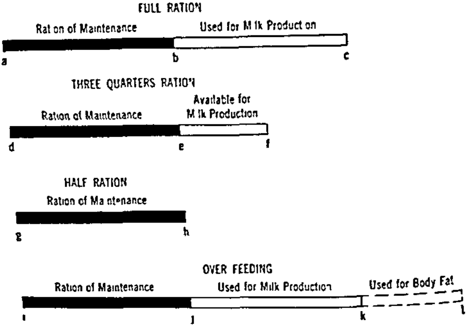

FIG 80 The economy of liberal feeding A good cow requires about half her ration for maintenance, leaving half for milk production If her ration is reduced 25 per cent, the cut comes entirely on that available for milk, which is reduced 50 per cent Producing milk requires first the nutrients for maintenance then as much more nutrients as the cow can utilize for manufacture of milk. If fed more liberally than her capacity to produce milk, she gains in weight. Economical feeding consists in supplying all the feed the animal will use for milk production Economy is achieved by feeding in proportion to milk production

quality that all the feed she can eat in excess of that required for maintenance is used for milk production

The third line represents what would happen if the feed of this animal were reduced one fourth The ration of maintenance remains practically the same as in the first case The amount represented by the line d to e is the amount required to maintain the animal's body, which is the same quantity as in the first case, however, the cut of

one fourth in the ration will be seen to come entirely on that available for milk production, and reduces that amount one half.

Drawing on Reserve. Suppose that the ration of such a cow be still further reduced to one half of the full ration, or that required for maintenance alone, as represented by the third line. In this case the cutting down of the ration one half would remove all available feed for milk production. However, the animal would not cease producing milk at once. This is a point of great importance in feeding cows, and a lack of such knowledge leads to serious errors in feeding. The milk-producing function is so strong that the cow will continue to produce milk for some time, even when the feed is insufficient, utilizing the reserve nutrients stored in the body previously. The cow will lose in body weight, and growth of young cows actually be retarded. This always happens in the case of a heavy-milking cow during the first few weeks after calving. T. L. Haecker[2] and J. L. Hills[3] observed that this period of declining weight due to insufficient feed intakes to meet milk requirements persisted through eleven weeks, more or less, varying with individuals. See Fig. 80.

Avoid Overfeeding. The bottom line of Fig. 80 indicates feed of maintenance in *i* to *j*, feed usable for milk production as *j* to *k*, and the portion offered in excess of requirements *k* to *l* that is converted into body fat. It is not economical nor desirable to fatten dairy cows with the expensive feeds which are fed to cows in milk. That portion of the feed represented by the line *kl* should be taken from the daily ration, so as to feed only that needed for maintenance and milk production. Errors of under- and over-feeding occur in every large herd. Heavy-producing cows may be underfed and light producers overfed and allowed to accumulate excess fat.

On the other hand, continued underfeeding of protein caused the cows to lose in body weight. The Minnesota[4] and Florida[5] stations

[2] Haecker, *Investigations in milk production*. Minnesota Agricultural Experiment Station Bulletin, 79:89–148 (1903).

[3] Hills, Beach, Borland, Washburn, Story, and Jones, *The protein requirements of dairy cows*. Vermont Agricultural Experiment Station Bulletin, 225:3–199 (1922).

[4] Eckles, Becker, and Palmer, *A mineral deficiency in the rations of cattle*. Minnesota Agricultural Experiment Station Bulletin, 229:5–49 (1926).

[5] Becker, Neal, and Shealy, *Effect of calcium-deficient roughages upon milk production and welfare of dairy cows*. Florida Agricultural Experimental Station Bulletin 262:3–28 (1933).

found that inadequate supplies of either calcium or phosphorus cause withdrawal of these minerals from the skeletal reserves, weaken the bones, and ultimately restrict milk yields

In the first few weeks after calving, it is not generally possible to feed the cow sufficient feed to supply the nutrients necessary to pro-

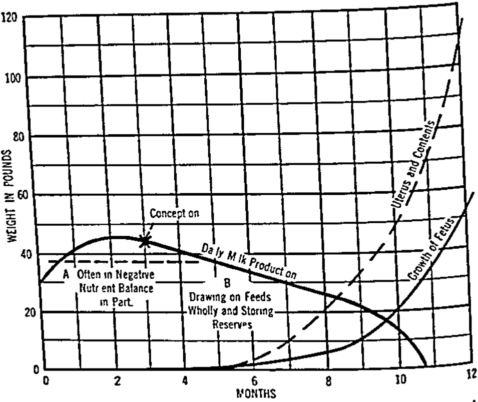

FIG. 81 The cow draws on reserves of nutrients in the body for a few weeks after calving. (*a*) These are restored later in lactation, (*b*) and during the dry period Some months after conception, milk yields decrease sharply as the fetus and uterus and its contents gain in weight prior to calving.

duce the milk Even if the feed were offered, the appetite usually is insufficient to prevent loss in weight As a rule, all heavy milking cows decline in weight for the first two to ten weeks after calving, which means that milk production exceeds the food nutrients supplied for that purpose, above the ration of maintenance The same thing happens with a cow receiving a ration insufficient for the amount of milk she produces She may continue for a time by drawing on body

reserves, but soon milk production must come down to the amount of nutrients available for this purpose above body maintenance. When feed is eaten in excess of requirements, the cow begins to store reserve materials in her body.

Feeding would be simpler if cows were to produce only the milk provided for by the nutrients consumed daily in excess of maintenance needs.

Feeding as Individuals. It is possible to feed cows economically only when they are fed as individuals, and not as a herd. Consideration should be given to length of time in milk, quantity, and butterfat content of each cow's milk. If all cows were fed alike, the higher producer would receive too little feed and would soon decline in daily yield, while the lower producer would be overfed and accumulate body fat. Production of many herds could be increased by distributing feed among individuals according to needs. It requires attention to adjust the ration to each individual, but the time required gives good returns.

Relation of Live Weight to Proper Feeding. The live weight of a cow is one good index of whether or not the cow is being fed a proper amount; but good judgment must be used in regulating the ration by observing this condition. We must expect a cow to lose weight in the first few weeks of her milking period; but after this period is past, there is no reason why she need change greatly in weight for several months. This is the period when the greater part of the milk production is secured. The animal should be allowed to gain in weight during the latter end of the milking period; this is necessary on account of the development of the fetus, and because it is natural for the animal to carry some fat on her body at calving time.

It does mean, however, that in order to feed a herd of cows economically, it will not do to feed them all the same quantity of grain whether giving a gallon of milk a day or four gallons. It also means that when a cow in the middle of her lactation period is putting on weight she is being fed more than she needs and will give just as much milk if the feed is cut down somewhat. It also means that if a certain animal is losing in weight, sufficient feed is not being given, and that if the deficiency is not supplied, it will not be long

before the milk production will come down to correspond with the amount of feed available

Weight Changes from Gestation A distinction exists between weight increase due to fat storage and those arising from advancing gestation The Nebraska[6] and Florida[7] stations have determined weight changes of cows attributable to stage of gestation

Including involution of the uterus after calving with Jersey cows, added weight of the fetus, fluids, membranes, and growth of uterus amounted to

Stage of pregnancy, in days	90	120	150	180	210	240	Full Term
Increase in weight, lbs	5	12	22	31	43	75	122

Such changes of weight due to advance in gestation (see Fig 80) should not be regarded as *fattening* Underfeeding because of these weight increases would be at the expense of the cow's own body, which would be depleted to produce the calf

Amount of Grain and Roughage to Be Fed The cow, being adapted by nature for consuming bulky feeds, does not feel satisfied unless there is sufficient bulk to the ration at all times An animal that is fed too much grain in proportion to the amount of roughage may seem hungry, while really she has a sufficient amount of nutrients but in a form so concentrated that it does not have sufficient bulk The cow should be fed practically all the roughage she will eat up clean, at all times, and the difference in the rations fed to cows producing different quantities of milk should be in the grain ration

A cow on a good ration of roughage will maintain herself and produce a certain amount of milk If she be a cow of much dairy capacity, she will not produce milk to anything like her maximum without having a portion of her ration in the form of concentrates The point is, the milk producing function has been developed to such an extent that it is impossible for the digestive apparatus of the cow, efficient as it is, to extract sufficient nutrients from coarse feeds

[6] Morgan and Davis *The effect of pregnancy and parturition on the weight of dairy cows.* Nebraska Agricultural Experiment Station Research Bulletin, 82 (1936)

[7] Becker Dix Arnold and Marshall "Changes in weight of the reproductive organs of the dairy cow and their relation to long time feeding investigations." *Journal Dairy Science* 33 911–917 (1950)

to supply the enormous drain upon the body resulting from secretion of large quantities of milk. Another point to rememb that even the best hay may not provide a cow with sufficient phosphorus because when on almost an exclusive hay ration phosphorus deficiency is most likely to develop. When the milk production does not exceed twenty pound daily, dairy cows can be successfully fed on good alfalfa hay and corn silage as the sole ration.

The mistake is at times made of assuming that cows all receive the same ration when a uniform ration is fed. The difference in the amount of roughage consumed is generally overlooked in these cases, since the animals can eat at will. If a grain ration be increased which is already ample, the animal consumes less roughage and may not consume any more nutrients than before, although usually such is the case on account of the greater palatability of the concentrates. In herds where all cows receive the same grain ration, close observation will show that the light milkers are consuming less forage than the heavier milk producers. Since roughage is usually a cheaper source of nutrients than grains, it is desirable to have a liberal amount of this class consumed. The amount can be regulated by giving the animal all she can consume of the roughage and, in addition, concentrates to supply the nutrients necessary for the amount of milk she is producing.

Rules for Practical Feeding. The most accurate means of determining the amount of feed required is by calculation based upon one of the feeding standards as explained later. However, practical feeders seldom make extensive use of feeding standards, and for their use the following rules serve as a general guide for feeding.

1. Feed all the roughage the cows will eat up clean. The roughage should include a succulent feed and a legume hay.
2. Feed 1 pound of grain a day for each 3 pounds of milk by a Guernsey or Jersey and 1 pound to each 4 produced by a Holstein. Other breeds are intermediate. The grain mixture should contain at least three concentrates and more are desirable for high producers.

The rule concerning the amount of grain to feed applies only when good roughage is fed, including a succulent feed such as silage or

roots and legume hay In case inferior roughage such as a mature grass hay or corn fodder is used, the concentrate allowance should be somewhat heavier if a satisfactory production is to be maintained

SUCCULENT FEEDS AND WATER

The second condition typical of summer rations is that the feed be of a succulent nature The cow seems especially adapted for a feed of this character and seems to do her best when it makes up part of the ration The term "succulent" is applied to such feeds as grass, silage, and roots—feeds containing the original juices in contrast to those that have been dried A succulent feed has been supposed to have a value because of its vitamin and mineral content outside of the actual nutrients it contains, and to have a favorable effect upon the digestion of the animal This value, however, may be overestimated and is probably mostly due to the additional water such feeds contain Cows do best when feeds contain a high water content or when a plentiful supply of good water is always easily available In the corn belt, corn silage and pasture have been the common feeds used to supply succulence In other regions, especially north of the corn belt, the growing of root crops such as mangels or rutabagas is widely practiced, and supplies this desirable addition to the ration in an entirely satisfactory form The preservation in silos of soiling crops in their most nutritive stage by direct addition of acid, molasses, or other preservatives is growing in favor Root crops are also to be recommended when the herd is too small to justify the erection of a silo

THE PROTEIN SUPPLY

The third reason for the excellent results from good pasture grass is that an ample supply of protein is available According to recent work,[8] spring grass is markedly superior to autumn grass for milk production because the protein has a higher quality Some attention may have to be given this finding in future dairy husbandry practice

On the ordinary dairy farm the most common mistake made in feeding, next to that of not feeding liberally enough, is the use of a

[8] Morris Wright and Fowler *Journal Dairy Research* 7 97–121 (1936)

ration that does not furnish the necessary amount of protein. Fresh pasture grass supplies sufficient protein, but the winter ration, especially where corn and timothy hay are standard, is often decidedly lacking in this constituent. The protein of the milk, a portion of which is seen as curd in sour milk, requires for its manufacture the same class of substances in the feed. Nothing else can take its place.

If a cow has sufficient other material in her feed to produce thirty pounds of milk, but, on account of a shortage of protein, produces but fifteen, it is useless and wasteful to increase the ration further. The proper procedure is to change the ration by the addition of a small amount of a concentrate high in protein.

The practical feeder should become familiar with the composition of the common feedstuffs and use this knowledge as a basis for selecting the ration to be used. The classification which follows will assist in fixing the relative value of common feeds in regard to the content of protein and total digestive nutrients.[9]

ROUGHAGE

High in Protein and Total Digestible Nutrients

	DIGESTIBLE CRUDE PROTEIN PER CENT	TOTAL DIGESTIBLE NUTRIENTS PER CENT
Alfalfa hay	10.5	50.3
Alsike clover hay	8.1	53.2
Cowpea hay	12.3	51.4
Lespedeza hay	6.4	47.5
Red clover hay	7.1	52.2
Soybean hay	9.6	49.0
Medium in Protein and Total Digestible Nutrients		
Corn fodder, well eared	3.8	58.8
Johnson grass hay	2.9	50 3
Kafir fodder, dry	4.5	53.6
Prairie hay, western	2.1	49.6
Sorghum fodder, dry	3.3	52.4
Timothy hay, early bloom	4.1	50.8

[9] By special permission of the Morrison Publishing Company, Ithaca, New York, from *Feeds and Feeding*, 21st Ed., by F. B. Morrison (1948).

Low in Protein and Total Digestible Nutrients

	DIGESTIBLE CRUDE PROTEIN PER CENT	TOTAL DIGESTIBLE NUTRIENTS PER CENT
Cottonseed hulls	0	43 7
Oat straw	0 7	44 7
Silages		
Corn silage, milk stage	0 9	13 0
Corn silage dent, well matured	1 3	20 0
GRAINS AND BY-PRODUCTS		
Cereal Grains and By-Products		
Low in Protein		
Barley, common	10 0	77 7
Corn, No 2	6 6	80 1
Hominy feed	7 5	81 4
Kafir	8 8	81 6
Oats, farm run	9 4	70 1
Rye	10 0	76 1
Wheat	11 1	80 0
Dried beet pulp	4 3	67 8
Dried citrus pulp	2 5	74 4
Medium in Protein		
Corn gluten feed	21 3	76 3
Dried brewers' grains	22.1	67 1
Dried distillers' grains corn	24 4	71 2
Wheat bran	13 7	67 2
Wheat middlings	16 1	78 9
High in Protein		
Cottonseed meal, 41 per cent protein	32 8	70 6
Linseed meal old process	30 8	77 2
Soybean meal solvent process	42 4	78 5
Skimmilk, dried	31 2	80 7

Palatability An animal will give the best results when it relishes its feed Often the dairy cow consumes less feed because it is not palatable A common example is feeding young heifers corn silage, timothy hay, and a limited amount of grain Although the heifers have all the feed necessary before them, they will limit the amount they consume to such an extent that normal growth will not be secured

The greatest variation in palatability occurs in the roughage. A chemical analysis shows little difference in composition between hay cut at the proper stage of maturity and that cut in a more mature condition. The real feeding value, however, is different on account of increased lignin and the loss of palatability. Coarse stems and the conditions of curing are also factors in the palatability of hay. The feeding value of hay depends almost as much upon its palatability as upon its composition and digestibility.

It is not unusual for some concentrates to be refused when first offered, although they are eaten readily when the animals become accustomed to them. Even corn silage is sometimes refused when it is first offered. Malt sprouts are among the most unpalatable of concentrates, the rye products are also in this class, although to a less degree. The concentrate part of the ration is usually more palatable when three or more kinds are fed in the mixture.

Variety. It is a common belief that an animal loses its appetite if continued on the same ration for some time. This condition does at times develop if the ration is confined to a single roughage and if the grain which is fed lacks variety. If a monotonous ration has been fed for some time, it is advisable to make a change to insure that the animal will continue to thrive. However, if a variety of feedstuffs is included in the ration, the animal does not tire of its feed and can be continued for long periods without change.

The most skilled breeders of high-producing cows select a ration carefully, giving attention to variety and succulence, and then make as few changes as possible. For a medium-producing animal, three grains in the mixture are sufficient. For a very heavy-milking animal, the number may be increased to five or six.

The discoveries regarding the differences in the quality of proteins offer a probable explanation of the favorable effect of having a variety of concentrates in the ration fed. Protein is made up of amino acids, of which about thirty are known, at least twenty-three of which are found in proteins. The animal has to have certain ones of these, in order to maintain itself, to produce milk, or to grow. Proteins from a single plant may be deficient in some of these amino acids. Corn proteins alone, for example, are deficient in some amino acids

because the chief protein entirely lacks some of them This fact, and the low protein content of corn explains, in part, why animals do not thrive *to advantage* on corn alone When the ration contains grains or by-products from several plants, the deficiencies of one plant are, to a certain extent, overcome by the components in the other plants, particularly if they represent different species This fact is partly balanced by conversion of some proteins into others during rumen digestion, as discussed in Chapter XXV

It is well to have feedstuffs from as many different plants as possible The advantages of variety are well known to experienced herdsmen A typical ration used for variety is composed of distillers' grain, wheat bran, oats, gluten feed, cottonseed meal, and linseed meal In this case, at least six plants are represented in the mixture

Proportion of Nutrients from Roughage The digestion of the cow is especially adapted for utilizing large quantities of roughage In fact, the real purpose of the cow as a servant of mankind is the conversion of coarse materials into food usable by man

Economically, it is desirable on the farm that roughages furnish the largest possible proportion of the ration Digestible nturients are as a rule supplied cheaper by roughage than by concentrates For example, with clover hay at \$20 00 a ton, 100 pounds of digestible nutrients cost about \$2 00, in corn at \$1 40 a bushel, 100 pounds of digestible nutrients cost \$3 10

There are conditions, however, under which the cheapest source of nutrients is not roughage, but grains The margin between the farm price and the retail selling price is much larger for hay than for grains Baling hay for market, hauling to the shipping point, and the cost of transportation and of selling at retail add a large margin to the original cost For this reason, where feed is entirely purchased nutrients have been cheaper in concentrates than in hay This condition has been common in the eastern states for several years In January, 1955, the Boston price of second cutting alfalfa hay was \$60 00, and of bulk hominy feed \$60 50 per ton At these prices, 100 pounds of total digestible nutrients in alfalfa cost \$5 96 and in hominy feed about \$3 71 Under these conditions one buying all the feed would choose to supply as many of the required nutrients as is

practicable in the form of grains. However, at least a minimum amount of leafy roughage is desirable for several good reasons.

The proportion of the total nutrients that a dairy cow can get from the roughage in a ration depends upon the amount of milk she is producing. With liberal feeding of good roughage—for example, corn silage and alfalfa hay for winter feeding and pasturage for summer—it is possible for a herd of well-selected cows of the special dairy breeds to produce an average of from 175 to 200 pounds of butter-fat in a year. As the production increases, the proportion of the total nutrients which must be fed in the form of concentrates increases. A herd of cows producing from 275 to 350 pounds of fat yearly receives about 45 per cent of its nutrients in the form of concentrates. Cows producing 600 pounds of fat require 60 to 65 per cent of their ration in the form of grain, while for a yield of 700 pounds of fat or more in a year, the proportion of nutrients from concentrates usually reaches 70 per cent.

This fact is an important consideration in the question of what level of fat production is the most economical. It is clear that if the cow producing 600 pounds of fat or above can do so only by using mostly grain, she does not meet the purpose of the general farmer, who uses the cow largely to convert his roughage into marketable products. On the other hand, on account of the overhead expense a very low-producing cow is not economical. Under farm conditions the most economical production is from 300 to 400 pounds of fat yearly.

In practical feeding it should be recognized that the concentrates should be fed in proportion to production and that high production inevitably means heavy feeding of concentrates.

Lightness of Ration. Among cattlemen the term "light ration" is used with two distinct meanings. The term "light ration" is used with the same meaning as "scant ration," or in contrast to a liberal ration. The other meaning, and the one covered by this paragraph, refers to the bulkiness of the feed mixture used; or another way to define it is weight in proportion to volume. In this sense, a light ration is one that has a large bulk in proportion to its weight, and a heavy ration is the reverse. Ground oats, bran, and dried beet pulp are examples

of light feeds, cottonseed meal, corn gluten meal, and soybean meal are examples of heavy feeds The general character of the ration regarding lightness will depend upon the proportion present of the heavy and light feedstuffs When roughages are limited or costly, more bulky concentrates may contribute to the ration

When the amount of grain fed is very limited, no special attention to the character of the ration regarding lightness is necessary, but for high producing cows receiving a liberal ration it should be taken into account A heavy-milking cow may receive up to twenty pounds of grain daily With such an amount to handle, it is not surprising that every precaution must be taken to make conditions as favorable as possible for digestion Bran and ground oats are especially useful to assist in lightening the ordinary ration Dried beet pulp and dried citrus pulp are the most effective of all common feeds in this respect For this reason, where cows are receiving very heavy grain rations, sometimes beet pulp is made a part of the ration

Home-Grown Rations The dairy farmer is averse, as a rule, to buying any more feed than is absolutely necessary In general this is right, although in case the home-grown ration is clearly inadequate it will be economy to buy what is necessary to get fair results The proper course for him is to grow crops that will supply the necessary constituents of the ration as fully as possible

The foundation of a good ration anywhere is good silage and a legume hay A succulent feed of some kind contributes greatly as a major part of the total feed

One reason why many farmers make the mistake of feeding rations short in protein is that they often grow feeds that are high in carbohydrates and lacking in protein This is due principally to the large amounts of grass hay and corn grown and used A ration including corn fodder or silage, timothy hay, and corn would maintain a dry cow in good condition, a dairy cow, however, could produce but little milk even if fed such a ration liberally With such a combination of home-grown feeds, the addition of rather liberal amounts of high protein feeds such as gluten feed or meal, linseed, cottonseed, or soybean meal would be the only possibility of holding up milk production The thing for the farmer to do is to raise on his own farm as far

as possible the feeds he requires. It is possible in many localities to produce practically all that is needed to make a balanced ration. The place to begin in considering the feeding of an animal is always with the roughage at hand, since the character of the roughage determines to a large extent the kind of grain it is advisable to feed.

The cheapest source of home-grown protein usually is leguminous hay. The kind to be grown varies with locality. The most common legumes are alfalfa, red clover, sweet clover, lespedeza, soybeans, and cowpeas. If an abundance of any one of these hays can be grown the problem of making an economical balanced ration is very greatly simplified.

Corn is the greatest staple crop of the country. Either oats or barley is generally available. Corn silage or roots to supply the succulent feed, and clover, alfalfa, or other legume for the remainder of the roughage give the foundation for a satisfactory economical ration. Corn, oats, and barley, fed in a mixture including at least two of the three, supply the basis of a good grain mixture. From these alone can be made a ration satisfactory for a low-producing herd.

The addition of a small quantity of a concentrate rich in protein, such as bran, cottonseed meal, or soybean meal makes a ration adapted to heavier milk producers

CHAPTER XXVII

Feeding for Milk Production

(*continued*)

FUNCTIONS OF NUTRIENTS

Function of Carbohydrates The chief function of the carbohydrates in foods is to supply energy to carry on the life processes, to maintain the warmth of the body, to build adipose or reserve tissue, and in the case of lactating animals to furnish materials for the milk sugar and butterfat in the milk The ordinary feeding stuffs contain an abundance of carbohydrates An adequate supply of energy will be provided when the feeder follows the feeding standard

Function of Proteins The proteins of the ration are utilized to replace worn-out tissue and to build new tissue as the animal grows It is the specific amino acids (parts of proteins) in the food proteins which are used for these purposes In addition, the highly specialized cells and organs also demand specific amino acids in order to continue their normal functions Unless the proteins in the food furnish these substances in adequate amounts, physiological disturbances result When the total energy supply in the food is deficient, amino acids are used for energy, and even under normal feeding conditions, surplus amino acids are employed for this purpose During lactation the food proteins are needed for the formation of milk proteins and may even be converted to form milk fat

In the process of protein digestion, the animal and vegetable proteins are broken up into the amino acids, twenty-three different

kinds of which have been isolated from proteins and identified, and a number of others are known whose existence in proteins has not been established. So far, only ten of the known amino acids have been shown to be indispensable components of dietary proteins. It is known that synthesis of many of the amino acids can and does occur in the animal body. However, from the large number which cannot be formed in the body, it is plain that the quality of the protein in the diet is just as essential as its quantity. Indeed, by a judicious mixture of protein feeds, assembled on a basis of their relative amino acid content, it is possible to reduce greatly the actual amount of protein necessary to satisfy the nutritional demands of an animal.

Protein Limitations. The limiting factor in the protein diet of an animal may be the amount it contains of one of the amino acids indispensable in the diet, and if the quantity of one is insufficient, no amount of the others will compensate for this specific deficiency. Microorganisms in the rumen make some amino acids from the nitrogenous feedstuffs, and thus reduce in part the importance of the ten essential amino acids in the cow's ration. Therefore, the previous insistence on variety in proteins in dairy feeds loses much of its former importance, except in the ration of the very young calf. During the growing period there is greater need for protein and the proportion of protein in the ration should be greater than when the animal is mature. Lactation calls for additional proteins and possibly for a different assortment of amino acids to furnish those which go into the casein, albumin, and the lesser proteins of the milk. The modern feeding standards specify amounts which are at least adequate for these purposes.

Function of Fats. Until recently fats have not been regarded as furnishing any specific nutrients other than being an especially rich source of energy. It has been assumed that the animal body possesses an unlimited capacity to produce, from the food carbohydrates and fats, the fat constituents of the body. Recent work points to a limited capacity of animals to form certain of the unsaturated fatty acids which are apparently needed for specific purposes. Fortunately these are abundant in many of the feedstuffs commonly fed to dairy cattle, especially the grains and protein concentrates. The importance of

food fat in the production of milk fat is receiving renewed attention, although it is still recognized that food carbohydrates play an important role in this regard

MINERAL MATTER

Functions of Mineral Matter Mineral elements are small but essential parts of the body for structural and functional uses In fact, animals can survive on water alone for a longer time than on a ration devoid of all essential mineral nutrients Feeding once was expected to supply sufficient amounts of protein and total digestible nutrients It was known that some minerals were required, but sufficient amounts were assumed to be present in the feeds providing the necessary protein and digestible nutrients Evidence has accumulated showing that consideration must be given to mineral supply with respect to the soils upon which the feeds are grown

A number of mineral elements are needed by the body, including calcium, phosphorus, magnesium, potassium, sodium, chlorine, sulfur, iodine, manganese, iron copper, cobalt, and perhaps others

The skeleton is composed of, and also serves as a storage place for calcium and phosphorus These elements are important minerals of blood lymph, and milk The red corpuscles of the blood and red tissues of the body are rich in iron Copper helps utilize iron in hemoglobin synthesis, and functions in other ways Cobalt is needed for formations of new red blood corpuscles, for Vitamin B_{12}, and to stimulate appetite Without the chlorides of calcium, potassium, and sodium, the heart would not beat Sulfur occurs in all body proteins, and is obtained largely from feed proteins Phosphorus is in every body cell, where it has a vital part in life processes Control of all muscles is accomplished through action of certain mineral elements Nerve tone depends partly on available calcium Common salt supplies both sodium and chlorine for all body fluids, for osmotic pressure, and to aid in digestion Other functions of these minerals in the body include carrying oxygen, maintaining neutrality of the blood activating enzymes, contributing to metabolism of protein and carbohydrates Growth of new tissue involves all the nutritional mineral

elements, especially calcium and phosphorus for the bones and teeth. Milk contains a number of mineral elements, particularly calcium and phosphorus.

Calcium and Phosphorus. With dairy cattle the critical periods are during growth and when secreting milk. The mineral elements of which there is more frequent deficiency are calcium and phosphorus.[1] Three fourths of the mineral matter of the animal body is made up of calcium and phosphorus, and it is these elements which are most often lacking in the ration. Care should always be taken to require growing calves to consume sufficient calcium-containing roughage to insure an adequate calcium intake when their milk has been replaced by a grain ration. Good quality sun-cured hay also will usually provide a sufficient amount of vitamin D, also lacking in grains, to insure the assimilation of both calcium and phosphorus consumed. The following table[2] shows the amounts of dry hay that should provide the daily calcium needed by growing heifers.

Table 59. Dry Hay Daily to Provide Calcium Needs

BODY WEIGHT	HAY WITH 2.0 PER CENT CALCIUM	HAY WITH 1.5 PER CENT CALCIUM	HAY WITH 1.0 PER CENT CALCIUM	HAY WITH 0.5 PER CENT CALCIUM
Lbs	Lbs	Lbs.	Lbs	Lbs.
400	1.1–2.5	1.5–3.3	2.3–5.0	4.6–10.0
600	1.0–2.1	1.3–2.8	1.9–4.2	3.8–8.4
800	0.78–1.8	1.0–2.4	1.6–3.6	3.1–7.2
1,000	0.65–1.3	0.87–1.8	1.3–2.6	2.6–5.3

The best alfalfa will contain from 1.5 to 2.0 per cent calcium; red clover, soybean, and cowpea hay 1.0 to 1.5 per cent; lespedeza 0.5 to 1.0 per cent; prairie hay 0.4 to 1.0 per cent; and timothy hay 0.12 to 0.5 per cent. If the available roughage is too poor in calcium to insure the needed calcium intake, it should be fed for its vitamin D content, especially during the winter months, and the balance of the needed calcium provided by mixing high-grade limestone or other safe source of calcium with the grain ration. Such supplements usually will contain at least 35 per cent calcium.

[1] Minnesota Agricultural Experiment Station Bulletin 229 (1926).
[2] Mitchell and McClure, National Research Council Bulletin 99,85 (1938).

The cow in milk uses a large amount of calcium in comparison with other domestic animals Milk is rich in both calcium and phosphorus, serving as one of the best sources of these elements for human use The amounts present in milk vary slightly as do other constituents, but they cannot be influenced by the amount contained in the ration received by the animal[3] It seems safe to conclude from available evidence that a cow's daily needs for calcium and phosphorus will be satisfied by three-fourths gram of each element in the feed for each pound of milk produced in addition to the maintenance requirement, which has been estimated as about ten to fifteen grams of each element in the feed each day

In case the amount of calcium or phosphorus in the feed is not sufficient, the cow draws on reserves in her skeleton One of the striking facts concerning this subject is the extent to which calcium and phosphorus can be stored in the body in times of plenty and drawn upon in times of deficiency Hart, McCollum, and Humphrey[4] reported a case, on a ration low in calcium, of a cow actually giving off calcium in her milk until 25 per cent of the total in her skeleton was used The skeleton reserves of phosphorus were necessarily reduced also

Forbes[5] found that the heavy-milking cows used in his experiments regularly gave off more calcium than they received in their feed while in the early part of the milking period, regardless of how they were fed The reserves were replenished when the cows were dry or giving a small amount of milk. The recognized importance of having the cow dry for a period and of conditioning the animal before calving may be largely a matter of allowing the mineral reserves to become replenished

Later studies by Forbes[6] show the difficulties in determining experimentally the need for calcium and phosphorus supplements by cows producing 10,000 to 15,000 pounds of milk a year Moreover, the studies not only supported his earlier work showing almost invariable

[3] *Journal Dairy Science* 10 169–175 (1927)
[4] Wisconsin Agricultural Experiment Station Research Bulletin 5 (1909)
[5] Ohio Agricultural Experiment Station Bulletin 295 (1916) 308 (1917) 330 (1918) *Journal Biological Chemistry* 52 281–314 (1922)
[6] Forbes and associates Pennsylvania Agricultural Experiment Station Technical Bulletin 319 (1935)

losses of these elements, especially calcium, from the body in early lactation, regardless of adequate intake, but they likewise demonstrated that unsupplemented rations of timothy hay and grain mixture containing approximately 0.3 per cent calcium and phosphorus (dry-matter basis) apparently sufficed for one year for nearly 12,000 pounds of milk and the development of a calf. Like rations containing limestone or bone meal supplements or containing alfalfa hay as the roughage, with or without these supplements, gave indications of improved annual mineral balances when the supplements were included. An average dry period of two months was included in the calculation of the annual mineral balances but not the calcium and phosphorus in the calf.

More decisive effects of mineral supplements on the annual calcium and phosphorus balances were obtained by Ellenberger.[7] The cows were giving 10,000 or more pounds of milk. Calcium and phosphorus in the newborn calf were estimated and the cows allowed dry periods of nine to sixteen weeks. Most of the cows had at least one annual cycle without mineral supplement and one in which two and one-half ounces each of bone meal and limestone were added to the basal ration of timothy hay, corn silage, and grain mixture. Silage was replaced by green grass cuttings in the summer. The mineral supplements did not prevent the early lactation losses of calcium from the body, but in general the total yearly balances were either changed from negative to positive or positive balances greatly increased. Phosphorus balances on unsupplemented rations were decreased in these experiments but not to negative values.

Minerals in Relation to Reproduction. The belief was formerly held that cows receiving less than a certain amount of calcium in the ration could not carry their calves to term. This has not been substantiated.[8] The somewhat related idea that calcium deficiency increases the susceptibility to contagious abortion in cattle has no reliable experimental proof. The low calf crop in dairy herds in

[7] Ellenberger, Newlander, and Jones, Vermont Agricultural Experiment Station Bulletin 331 (1931); *ibid.*, Bulletin 342 (1932)

[8] Fitch, Boyd, Eckles, Gullickson, Palmer, and Kennedy, *Cornell Veterinarian*, 22 156 (1932); Palmer, Fitch, Gullickson, and Boyd, *Cornell Veterinarian*, 25:229 (1935).

phosphorus-deficient regions is not due to irregular estrum or failure of the cows to ovulate,[9] although breeding efficiency seems to be somewhat impaired Complicating deficiencies, as yet undetermined are evidently responsible

Supplying Common Salt General practice on many farms has been to salt the cows at frequent intervals or to place a block of compressed salt conveniently for free access One per cent of common salt often included in home mixed or commercial dairy feeds is insufficient for the needs of medium to heavy milking cows Dry cows bulls and all growing animals need continual free access to common salt Cattle prefer loose salt from a sheltered box rather than hard compressed block salt Iodized salt is used in goiter areas

Supplying Calcium and Phosphorus It should be understood that the cow gets most of her calcium from the roughages Legumes are the best source of calcium of all feeds used Corn and cereals and their by products on the other hand are low in calcium but in general carry a rather liberal amount of phosphorus One hundred pounds of alfalfa hay contain from 450 to 680 grams of calcium and 100 pounds of corn only 4 5 grams One pound of alfalfa supplies approximately the same amount of this mineral element as 100 pounds of corn The best sources of phosphorus are wheat bran cottonseed linseed and soybean meals although corn and oats also contain a fair amount Table 68 in the Appendix gives the calcium and phosphorus content of common feeds The amount of available mineral matter in the soil fertilizer applications and the amount of rainfall are important factors Forage crops grown on acid soil or sandy soil are lower in calcium than those grown on better soil Prairie regions in many parts of the world are deficient in available phosphorus When cattle are fed largely on hay grown in these regions they are certain to suffer from phosphorus deficiency and sometimes from lack of calcium especially if the hay is made from the native grasses The phosphorus content of legume hays grown in such regions is also lower than normal A deficiency of rainfall also results in a decreased calcium and phosphorus content of the crop

[9] Eckles Palmer Gullickson Fitch, Boyd Bishop and Nelson, *Cornell Veterinarian* 25 22 (1935)

grown. This is due in part to the fact that the plants mature before normal amounts of these mineral elements are taken up from the soil and also the fact that the calcium and phosphorus content normally decreases greatly as maturity is reached. The dry matter of plants in the early stages of growth is always much richer in calcium and phosphorus than when the plant is mature. The effects of soil deficiency and drought on the calcium and phosphorus content of the plants are limited chiefly to the forage. The grains and seeds are little affected in this respect.

Symptoms of Calcium and Phosphorus Deficiency. Sometimes it is difficult to recognize borderline calcium deficiency, because of the few well-marked symptoms. Occasionally quite definite conditions are noted. Broken bones, low milk yields, and too frequent occurrence of milk fever often are associated with calcium deficiency, when indicated by character of the rations, the character of local soils, and herd history. These conditions are associated with either depletion of skeletal reserves or low calcium storage.

In phosphorus deficiency there is first a lack of appetite for roughage and later the cows will show a craving for bones or bone meal, if available. If this craving is not satisfied, it will be followed by a desire to eat dirt, chew wooden mangers, fence posts, leather, and to devour any sort of rubbish. Such animals are often stiff and have an unthrifty appearance. The blood will always be low in inorganic phosphorus. Weakened and broken bones also may be observed. If a well-fed herd should milk poorly in comparison with former years, and especially if a tendency should be observed for the animals to have an unthrifty appearance, a shortage of phosphorus is suggested.

Minerals in Relation to Milk Production. In ordinary herds there is little danger of a calcium shortage if sufficient amounts of legume hays are used. It is probable that very heavy-milking cows, however, may at times be unable to assimilate sufficient calcium from this source. Legume hay fed alone or with corn silage as the sole ration will not supply enough phosphorus for heavy-milking cows. Five cows at the Minnesota station[10] averaged 3,587 pounds of milk

[10] Eckles, Gullickson, and Palmer, Minnesota Agricultural Experiment Station Technical Bulletin 91 (1932).

and 142 pounds of butterfat in a lactation period when on a phosphorus-deficient ration, and averaged 6,830 pounds of milk and 275 pounds of butterfat in a like period of their subsequent lactation when adequate phosphorus was consumed There was no other difference in the character of the ration, although the amount was adjusted to the level of milk production

There is no evidence as yet that adding bone meal or limestone or commercial mineral mixtures will increase milk production when added to rations containing adequate amounts of calcium and phosphorus

Calcium and Phosphorus Supplements Only when cows cannot be supplied necessary calcium and phosphorus from available natural feeds should mineral supplements be given If calcium only is needed, it is best to supply it as pulverized limestone, marl, marble dust, or other inexpensive forms of calcium carbonate A satisfactory product should contain at least 70 per cent calcium carbonate, and be free from fluorine Dolomitic limestone which occurs in some localities may contain as high as 40 per cent magnesium carbonate Magnesium cannot replace calcium in the animal body, although it is an essential mineral element Even if the ration contained no calcium, which would be impossible, one ounce of calcium carbonate daily furnishes all the calcium needed for maintaining the calcium in the body of a milking cow, and three ounces will maintain her body calcium and supply the calcium for 40 pounds of milk Marl or limestone should be mixed with the grain or self-fed mixed with salt The limestone-sodium chloride mixture to use is, at best, empirical, but a fairly satisfactory rule is to make the proportion of limestone equal to the proportion of total calcium needs which are lacking Thus if half the needed calcium is lacking, the mixture would consist of equal parts salt and limestone

Cows which require additional phosphorus will usually supply their own needs if given access to bone meal Natural rock phosphates, in general, should be avoided Most of them contain injurious amounts of fluorine The use of proper defluorinated rock phosphate and other low-fluorine forms will provide calcium and phosphorus safely and thus may help insure a longer usefulness of animals in the

herd. The mineral phosphates are not very palatable to cattle when fed alone. When phosphate-carrying products are fed mixed with salt the amount eaten seems to be governed by the appetite for salt. Many commercial mineral mixtures are sold at a price which is excessive for both the salt and phosphorus contained. Mixing salt and other minerals, including bone meal, would be more logical if the needs for the various components were always in the same proportions, which is not true. Mixtures of four parts phosphate minerals and one part salt have been recommended, although this or any other proportion is also empirical. Were no other phosphorus available than a bone meal containing 12 to 14 per cent phosphorus, the bone meal-salt mixture needed for maintenance would be approximately four parts bone meal and one part salt, but for milk production it would be more nearly 7.5 parts bone meal to one part salt. When such mixtures are used, salt should be made accessible separately, except in high-salt regions.

It is always preferable to supply needed phosphorus in the form of phosphorus-rich feed, because this will give the cow the advantage of other valuable food substances. Phosphorus-rich feeds are also almost always rich in proteins and certain of the vitamins. Wheat bran, linseed, cottonseed, and soybean meals are the logical phosphorus-rich feeds for dairy cattle.

Iron, Copper, and Cobalt. Certain types of soil in some regions may lack one or more of these three trace minerals. Conditions known as "salt sick" in Florida,[11,12] "neck ail" in Massachusetts,[13] and "lake shore disease" in a part of Michigan are known to be due to lack of one or a combination of the minerals iron, copper, and cobalt. Similar conditions occur among livestock in some other states, islands, and countries on deficient soils. This condition among cattle is characterized by an anemia, rough hair coat, loss of appetite, and loss of flesh due to voluntarily inadequate feed consumption.

Iron is the oxygen-carrying element of blood, vital red organs of

[11] Becker, Neal, and Shealy, Florida Agricultural Experiment Station Bulletin 231 (1931).

[12] Neal and Ahmann, *Journal Dairy Science*, 20 741–753 (1937).

[13] Archibald, Kucinski, Brooke, and Freeman *Journal Dairy Science*, 21 57–68 (1938).

the body, muscle, and is present in two of the bile salts. Copper has a catalytic action in utilization of iron. It is involved in hair pigmentation, in the protective coating of the skin, in nervous co-ordination of muscles, and in heart action. Cobalt is involved in the development of new red blood corpuscles in the red bone marrow, in the composition of vitamin B_{12}, and in appetite of animals. These three trace minerals are important in reproduction (growth of the fetus) and growth of young animals.[14] Milk contains them in only limited amounts. Lack of any one of these elements ultimately results in anemia.

Experiment stations in these regions have developed mineral supplements appropriate for the respective deficiency areas and should be consulted concerning local recommendations. Since copper and cobalt compounds are toxic in quantity, and since adequate intakes are extremely small, one should seek advice of informed persons before using them. Use of these trace mineral elements is neither necessary nor beneficial under many circumstances on adequate soil areas. A heifer suffering from cobalt deficiency and its correction are shown in Figs. 82 and 83.

Iodine. Iodine is contained in the hormone thyroxine in the thyroid gland from which it was first isolated and identified by Kendall in 1914. This hormone functions in basal metabolism of the body, and is important in development of the fetus in mammals. Less than 0.3 parts of iodine are present per million parts of body weight, half of this being in the thyroid while the remainder is distributed throughout the body. The iodine content of milk is small, varying with feed supply.

Shortage of iodine causes an enlargement of the throat where this gland is located on either side of the windpipe just below the larynx. Iodine deficiency is indicated when calves are born with goiter. Feed and water supplies are low in this element on the older geological soils inland on large continents. These include the Alps in Europe, Great Lakes drainage basin, Height of Land in Minnesota and west

[14] Becker, D. x Arnold, Kirk, Davis, and Kidder. *Minerals for dairy and beef cattle.* Florida Agricultural Experiment Station Bulletin 513 (1953).

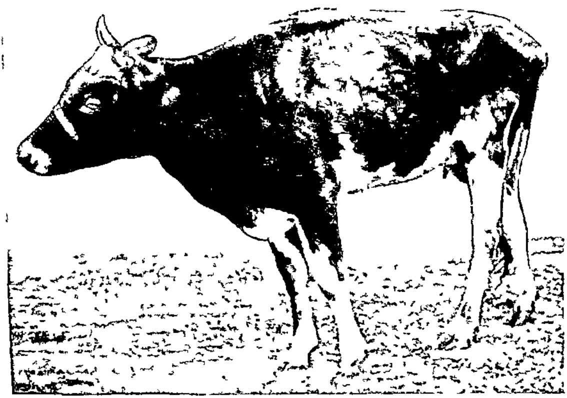

FIG. 82. A heifer suffering from cobalt deficiency Emaciation is due to lack of appetite for grain and roughage, preventing satisfactory development

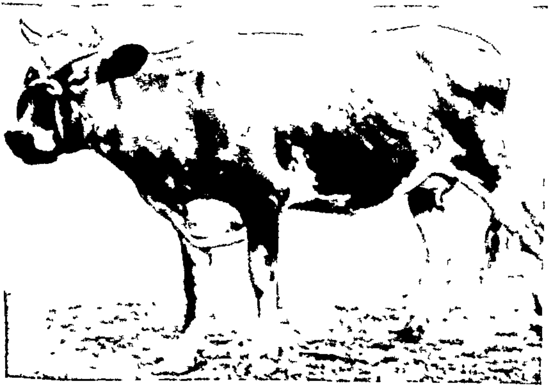

FIG. 83 The same young cow after having been supplied with the deficient cobalt needed in feeding

ward into the Bitter Root mountain range in the west, the Andes mountains and other similar areas world-wide

Where iodine supplements are needed, one ounce of calcium iodine or potassium iodide added to 300 pounds of salt (0 02 per cent potassium iodide) appears to be sufficient to supply the requirements when iodized salt is self-fed Iodized salt for livestock is available commercially in areas where goiter occurs No advantage accrues from feeding iodine in excess Large excesses may be injurious The thyroid gland stores sufficient iodine for a four- to six-month period

Minerals Harmful in Excess Minerals harmful in excess include fluorine, lead, molybdenum, and selenium When natural phosphates high in fluorine are fed over many months or years to the same animal, excess fluorine is stored in the skeleton and teeth where other minerals buffer any ill effects for a time Beyond this point, the teeth wear irregularly, and are sensitive to cold water, feed consumption is reduced and the animals become unthrifty [15,16] Poultry tolerate more fluorine than do cattle

Lead paint and containers should not be used or left where animals have access to them Licking wet paint or old paint buckets has caused death from lead poisoning

Some residual muck or peat soils have a high molybdenum content, which is picked up to excess by forage plants When eaten in excess, it exerts a laxative effect on cattle, disrupts phosphorus metabolism, and causes animals to become unthrifty [17]

Certain soils in western Dakotas,[18] Wyoming, and other areas contain selenium, that is taken up selectively by certain plants Growth of hoofs and other effects have been observed among livestock using these forages

[15] Reed and Huffman *The results of a five year mineral feeding investigation with dairy cattle* Michigan Agricultural Experiment Station Technical Bulletin 105 3–63 (1930)

[16] Mitchell "The use of phosphorus-containing substitutes for bone meal in livestock feeding with particular reference to the fluorine hazard National Research Council Committee on Animal Nutrition Report No 10 1–5 (1943)

[17] Becker Dix Arnold Kirk, Davis and Kidder *Minerals for Dairy and Beef Cattle* Florida Agricultural Experiment Station Bulletin 513 4–51 (1953)

[18] Franke Rice Johnson and Schoening Preliminary field survey of the so-called "alkali disease of livestock. U S D A Circular 320 1–9 (1934)

VITAMINS

Functions of Vitamins. A great deal still remains to be discovered regarding the importance for dairy cattle of several of the known vitamins. However, it has been established that growing calves and also mature cows require both vitamin A and vitamin D.

Vitamin A. The minimum vitamin A requirements are estimated to be approximately 3.0 to 3.5 milligrams of the precursor carotene per 100 pounds of body weight for growth, and 5 to 9 milligrams per 100 pounds of body weight during the last three months of gestation. The carotene requirement is approximately 4 to 5 times as much as that of active vitamin A itself. Reports of vitamin A potency of alfalfa hay range from 3,500 to more than 22,000 units per pound. This decreases during storage and especially in warm weather. One pound of the best hay usually will supply the minimum daily needs of mature cattle and one-fourth pound the daily needs of a 300-pound calf. Vitamin A-deficient calves first develop night blindness and become unthrifty and stunted. The cow's reproduction is poor, and calves born are weak and often permanently blind. Cows can store large quantities of vitamin A (with some carotene) in the liver and similar large stores of carotene (with some vitamin A) in the adipose tissue, both of which are drawn upon in periods of dietary shortage. Most of this storage normally occurs when cows are on fresh green pasture, which is especially rich in carotenes. The vitamin A content of cured hay decreases gradually through oxidation while in storage. Well-preserved silages also are fairly good sources of vitamin A.

Vitamin D. A severe ricketslike disease will develop in calves which lack vitamin D. The onset is hastened and the disease is more severe if calcium and phosphorus are also deficient, especially when the calcium intake is too low, as in the case when the calves are overfed with grain without skim milk and sufficient hay. Ultraviolet rays from the sun acting on provitamin D substance in the skin of cattle and other animals produce vitamin D which is absorbed and used by the body. When the ultraviolet is especially abundant during the

summer, the extra vitamin D formed is stored for use when the vitamin D forming power of the sun becomes very low in midwinter However, calves receiving available sunshine throughout most of the year in all but the most northern latitudes of the United States probably do not lack vitamin D Care should be taken that calves receive direct sunshine during midday or clear days of the winter in northern latitudes unless the weather is too severe Sun-cured hay is an important source of vitamin D for calves It has been found that two to three pounds of such hay daily will protect calves from rickets up to one year of age Larger amounts, normally consumed by calves as age advances, provide any additional vitamin D required in the ration The hay normally received by mature cows, together with the sunshine obtained in good herd management, provides all the vitamin D they require Corn silage also contains some vitamin D available for calves

Vitamin E Vitamin E deserves special comment It has been demonstrated that goats, a species analogous to cattle, do not require this vitamin, which is definitely needed by rats for normal reproduction Knowledge is lacking whether cattle resemble goats or rats or are intermediate in their vitamin E requirements If cattle are like rats some of the vitamin may be needed for normal growth of both heifer and bull calves and definite amounts for normal sexual development of bull calves but not for heifers Dairymen seem to have acquired the impression that heifers and cows require vitamin E in order to conceive This not only has not been proved but is contrary to the behavior of laboratory rats in which the functions of the vitamin are definitely established Vitamin E tests conducted with rats have demonstrated the vitamin in most of the common dairy cattle feed stuffs in sufficient quantity to insure reproduction in the test species at only 20 per cent level in the ration This vitamin is undoubtedly stored in the body

Vitamin B complex In young cattle and cows with a fully developed rumen, the rumen flora make most of the vitamins of the vitamin B complex Recently, however, it has been shown that the young calf before its rumen has been developed requires riboflavin thiamine biotin and pantothenic acid for best health and growth

Vitamin B_{12}. Vitamin B_{12} is a complex member of the water-soluble vitamins. It contains cobalt and phosphorus as parts of its complex structure. Cobalt is related to appetite; it aids in formation of new red blood corpuscles in the red bone marrow, and along with iron and copper prevents anemia. Ordinarily, sufficient iron, copper, and cobalt are stored during fetal growth to last until the growing animal can obtain its daily requirements from leafy forages. Milk is low in these trace minerals.

PREPARATION OF FEEDS

Grinding Grain. The grinding of grains increases the digestibility only in case the animal would not thoroughly masticate the unground kernels. The cow in milk, receiving a liberal allowance of feed, fails to masticate a considerable proportion of whole grains such as corn or oats. The following results, obtained from tests made by Shaw and Norton,[10] are typical of what may be expected.

	COWS	HEIFERS	CALVES
Whole corn passed, per cent	22 8	10.8	6 3
Whole oats passed, per cent	12 1	5 5	3.0

The cows receiving a rather liberal ration showed a greater percentage loss than the heifers, while the calves showed much less loss. A loss of from 12 to 20 per cent in feeding unground grain, as indicated by this test, fully justifies the common practice of feeding ground feed almost exclusively to cows in milk. With calves the loss is not serious. It was also found in this investigation that the composition of the whole grain passed was changed but little. Germination tests showed that 4.3 per cent of the corn and 10.6 per cent of the oats would still grow. Tests with silages in Oklahoma and elsewhere indicate that cows utilize whole corn in silage rather efficiently.

The only condition under which it is economical to feed unground grain is when the price of the feed is relatively cheap and the cost of grinding high. If no hogs are on hand to gather up the grain

[10] Michigan Agricultural Experiment Station Bulletin 242 (1906)

otherwise wasted, it would ordinarily be economical when feeding cows in milk to spend, in grinding if necessary, a sum equal to 10 per cent of the cost of the grain fed Grains are more palatable when freshly ground than after prolonged storage in the ground form

Cutting and Grinding Hay and Fodder. The practice of running hay and straw through a cutting box is not practiced to any great extent in America This treatment has no appreciable influence upon the proportion of the hay digested Cut hay is not thrown from the manger and wasted by tramping to the same extent as the uncut A larger proportion of the coarser parts is also eaten Only under exceptional conditions, however, is the cutting of hay or fodder economical, such as when only very coarse roughage is available which the cows do not consume readily Baled hay should be chopped with great caution to prevent including some of the baling wire, one piece of which may prove fatal to a valuable animal Losses from this cause are very common

In recent years the grinding of alfalfa hay has become an important industry where this hay is grown abundantly The hay is reduced to about the mechanical condition of wheat bran and is sold sacked No increase in digestibility is secured by its use The idea, encouraged by those interested in its preparation that ground alfalfa ceases to be a roughage and becomes a concentrate cannot be accepted The ground hay is hardly as palatable for cattle as the unground, especially when it contains considerable dust The chief objection to alfalfa meal is its expense Grinding roughage is an expensive operation and the market price is considerably above that of baled hay This seems an unnecessary addition to the expense of the ration while the cow herself has a very good grinding apparatus and prefers to grind her own hay Only in the case of cows fed alfalfa hay alone, without any grain and concentrates is there evidence in favor of cutting the hay [20]

Cooking, Steaming, or Soaking Feed There is no advantage in cooking feed for cattle In fact some protein is somewhat less digestible after cooking The same statement applies to steaming of

[20] Jones Brandt and Haag Oregon Agricultural Experiment Station Bulletin 328 (1934)

hays, as any reduction in waste does not justify the labor and expense of the practice.

Under ordinary conditions nothing is gained by feeding the grain ration in a wet condition or as a slop. Dusty or unpalatable feeds sometimes are moistened with dilute molasses to improve palatability. It is often questioned whether or not any slight advantage gained will offset the cost of such preparation by hand.

FEEDING PRACTICE

Cause of Milk Secretion. As stated elsewhere, scientific investigation shows that milk secretion is primarily the result of stimulating hormones, the most important one being known as *prolactin*. A secondary factor in milk secretion is the action of the nervous system, stimulated by the act of milking, causing the formation and secretion of the chief lactogenic hormone. It was formerly believed that, in the early part of the milking period, hormones were the chief cause of the milk secretion, while in the later stages of the lactation period the stimulation from this source had largely died out and the nervous stimulation from milking was the chief factor. The new discoveries regarding the cause of milk secretion render these ideas untenable in their original concept, although they do not change the importance of certain established feeding practices.

The milk production of a cow is determined by two factors: the internal, or the stimulation applied to the udder from the inside, and the external, which includes feed and care. Having the cow in proper physical condition at time of freshening has been emphasized in another chapter. The strength of the internal factor is determined chiefly by heredity, but the physical condition of the animal at time of freshening modifies the intensity of this stimulation to a marked degree.

Proper methods for feeding the cow when she is dry have been discussed in a previous chapter.

Feeding after Freshening. After the calf is born, the cow should be given water, warmed if the weather is cold, and a small portion of roughage. The grain fed during the first few days should be light and laxative in character. A mixture of oats, bran, and linseed oil

meal fulfills these requirements After a few days the cow may be given the regular mixture received by the remainder of the herd, the amount to be increased gradually as her physical condition permits If the udder is congested, the grain must be kept to a low point until the inflammation subsides A small or medium-milking cow may be put on full ration within a few days, but a heavy-milking individual requires greater care Sometimes full feed is not given until the end of thirty days or even longer It is natural for a heavy-producing cow to lose in weight for a month or six weeks after freshening After this period she will decline in milk production gradually As gestation advances, milk secretion decreases more rapidly, as shown in Fig 80 Toward the end of lactation and during the dry period the cow should increase in condition and nutrient reserves for the next lactation

How Much to Feed The feeder should follow the milk production of the cow with the feed rather than expect the milk production to follow the feed The fresh cow gives milk as the result of the stimulation applied to her udder If in good flesh she will for a time milk liberally even if some nutrients have to be taken from her body for the purpose In fact, a heavy-milking cow is always underfed for a time Her ration should be increased as rapidly as seems safe, until enough nutrients are supplied for the amount of milk produced The secretion of milk takes large quantities of nutrients from the body, and the cow is very hungry A high-producing cow is a heavy eater because she requires the nutrients to replace those taken from her body to produce milk However, she is not a heavy producer of milk as the result of being a heavy eater

If the cow is in good condition when she freshens and is fed somewhere near the correct amount, she will show soon after calving what her capacity of milk production is If a cow produces 40 pounds of milk daily soon after being fresh, be sure to feed her enough to supply what is needed to produce 40 pounds of milk If she receives only enough for 30 pounds, she will draw on the nutrients stored in her body for a while, then gradually come down to 30 pounds The thing to do is to be sure to give her enough for 40 pounds while she

is producing that much. Many cows that are given a reputation for lacking in persistency of milking really do not hold up as they are capable of doing on account of lacking the proper ration. If a cow that is already receiving a ration ample to supply everything needed for the milk she is producing goes down in milk, she cannot be brought back by increasing the feed. The thing to do is to reduce the grain in proportion to her drop in milk. It should be remembered that giving the cow the proper ration to produce milk does not result in milk secretion unless the stimulation to give milk is present in the cow. In other words, follow the milk production with the feeding and do not assume that the milk flow can be pushed up and down at will with the feed. A common error resulting from a failure to understand these facts properly is to attempt to judge the value of a certain feed by putting it in the ration of cows already several months in milk. When a cow has largely lost the stimulation to give milk which she received at the time of freshening, the effect of a change of feed is slight. The amount of grain fed should be carefully adjusted as the milk production declines, due to the advance in lactation. If a cow goes down in milk and is already receiving sufficient feed, it is hopeless to attempt to bring her back by increasing the amount fed. The proper course is to decrease the grain allowance in proportion to the decline in milk production unless it is desirable to have the animal gain in weight.

Order of Feeding. The cow is a creature of habit, and responds best when fed and cared for at the same time each day. Regularity in time and manner of feeding is of more importance than any definite order of feeding. As a rule, about half of both concentrates and roughage should be fed at night and the remainder in the morning. The grain is usually fed first and the hay feeding reserved until after the milking is completed, to avoid filling the air with dust, which contaminates the milk. Silage should be fed *immediately after* milking, to prevent the odor from gaining access to the milk. The cow is a creature of habit, and prefers that the same routine always be followed. She may be taught to demand her grain ration when milking, but will give down her milk just as well if always fed either

before or after milking, and will not look for it at the time of milking. When heavy-producing cows are milked oftener than twice daily, the number of feedings is usually likewise increased.

LIMITS OF GRAIN FEEDING

The system of feeding dairy cows in this country calls for a liberal feeding of concentrates in the form of grain or by-products. The European practice, on the other hand, calls for a minimum allowance of concentrates, usually by-products, with a maximum feeding of roots or high-quality roughage. This wide variation in practice suggests that conditions such as price of feed, market value of product, and cost of labor must be the determining factors.

The evidence available indicates that with the best of roughage alone, for example corn silage and alfalfa hay, a herd of well-selected Holsteins may be expected to average 6,000 pounds of milk. The same herd, if given a reasonable amount of grain in addition, will average about 8,000 pounds. With heavy grain feeding and three-times-a-day milking, the yield can be further increased.

The question confronting the farmer who is interested in total profits rather than total yields is how liberally should grain be fed. Many factors are involved. One consideration is the producing ability of the cows. It is possible under favorable conditions to produce an average of 150 pounds of fat yearly on a ration consisting exclusively of roughage. A herd with the average capacity to produce only 150 to 200 pounds of fat can eat and digest nearly enough roughage to supply the requirements, and only a limited amount of grain is necessary in addition. If a large amount of grain is fed, the cow does not produce more milk because her capacity is limited. She merely eats less roughage and takes a correspondingly high proportion of her nutrients from the more costly grain.

On the other hand, given a cow with the capacity for high milk production, only under extreme and unusual conditions it is economical to limit her feed. Economy calls for a full use of her producing capacity. The overhead expenses in maintenance of the animal, the necessary labor, barn room, and other expenses have to

be met. These are practically the same when the cow is producing 150 pounds of fat as when producing 300 pounds.

The situation can be best illustrated by an example. Assume that Guernsey cows are on hand, with a capacity to produce 30 pounds of milk testing 5.0 per cent fat daily. By referring to the Morrison feeding standard[21] one may calculate the daily requirements for digestible crude protein and total digestible nutrients. A ration balanced to meet these requirements could be computed as follows:

	DIGESTIBLE CRUDE PROTEIN	TOTAL DIGESTIBLE NUTRIENTS
	Lbs	Lbs.
Maintenance, 1,000 pounds	0.65	7.90
30 pounds milk, 5.0 per cent fat	1.68	11.10
Total requirements	2.33	19.00
The daily ration		
Corn silage, 30 pounds	0.360	5.43
Alfalfa hay, 10 pounds	1.050	5.03
Corn, No. 2, 5 pounds	.330	4.05
Oats, 4½ pounds	.423	3.154
Wheat bran, 2 pounds	.274	1.344
Total nutrients	2.437	19.008

This ration meets the cow's requirements well for protein, but is barely adequate in total digestible nutrients, leaving no excess for fat storage. Supplies of calcium and phosphorus will be found adequate and it is rich in carotene. Adequacy of trace elements—iodine, iron, copper, and cobalt—depends on fertility of the soils on which these crops were grown, especially the leafy roughages. The cow will need free access to common salt, except in certain regions where the water and locally grown feeds contain some salt. The cost and availability of all feeds should be considered in calculating rations for dairy cattle.

Under anything like normal conditions, it is difficult to justify the withholding of grain when the cow has a capacity greatly beyond what she can maintain with roughage alone as a ration. Even if the additional milk will not more than pay for the feed, there will be a reduction in the cost per 100 pounds of milk, because the overhead

[21] F. B. Morrison *Feeds and Feeding*, 21st Ed., p. 1147 (1948).

charge will be distributed over a larger volume For example, if it cost $50 in addition in feed to keep a cow a year, this is $0 50 a hundred if she produces 10,000 pounds of milk, and $1 a hundred if she produces only 5,000 pounds

Grain Feeding in Irrigated Alfalfa Districts An interesting phase of the feeding problem arises in the irrigated regions of western United States Here alfalfa is grown in large quantities and is very cheap on account of its abundance and short distance from market Grain, on the other hand, is high in price The milk producer has his choice of feeding alfalfa exclusively or of supplementing with barley or other cereal at a rather high cost

The question is, should the farmer be satisfied with a production of about 5,500 pounds yearly from a herd of Holstein cows, or should he, by adding a limited amount of grain, secure an additional 2,500 or 3 000 pounds?

According to Woll, Voorhies, and Castle,[22] the practice of feeding concentrates of some kind in addition to the alfalfa is increasing—partly to secure a larger production, and partly on account of a belief that continued heavy feeding of alfalfa is detrimental to the breeding qualities of the animals Woll reports as the result of experiments that the method of feeding grain in the ratio of one pound to every five pounds of milk yielded within 5 per cent as good results as a ratio of one pound of grain to each three pounds of milk His experiments show that an increase of about 25 per cent in milk flow may be expected with good cows when alfalfa is supplemented with a limited grain ration and corn silage

The following statements aim to summarize the subject as far as the difficulties involved make such a procedure possible

The capacity of the cow to handle roughage is naturally limited Under the very best conditions, with roughage alone, an average production of from 150 to 175 pounds of fat is the maximum that can be expected except where the roughage is high grade alfalfa If the capacity of the cows for milk production is not greater than can be supplied with the necessary nutrients from roughage, it is not

[22] Woll Voorhies and Castle California Agricultural Experiment Station Bulletin 323 (1920)

economy to feed much grain. Under these conditions the addi grain results in the animal's depending upon this source of n to a greater extent and using less hay. If the animal has a capacity for milk production beyond what can be obtained from roughage, grain should ordinarily be fed.

In consideration of this question, the importance of the overhead expense should not be overlooked. The ration of maintenance is the same for light as for heavy production, and labor and other expenses nearly as great. After going to the expense of maintaining the cow, it seems wise economy to make a full use of her producing ability.

The experience of Europe as well as experimental work here indicates that in general a moderate grain ration is more economical than a very heavy grain ration. The rules suggested for feeding, one pound to each three or four pounds of milk according to the richness, if followed, will result in economical production under ordinary circumstances.

Unusual conditions may alter the value of such suggestions temporarily, or local conditions may be such that their application is questionable.

FEED AND CARE OF THE COW

Good yearly production is secured from high-producing cows only by the combination of the skilled herdsman, good feeding and management. Not all cows can be fed exactly the same. The likes and dislikes of individual cows must be considered.

Feeding the Dry Cow. Experience has emphasized strongly the importance of having each cow in good thrifty condition at the time of freshening. The cow should be dry for four to eight weeks. During this time she should receive a limited concentrate offering, expecting some gain in physical condition.

The ration should include some succulent feed and a grain mixture. During pasture season, good quality grass is the best roughage. When grass is not available, silage or roots may partly take its place. Alfalfa or other legume hay should be included.

The grain fed should be palatable, medium in protein content, and light or bulky. Feeding of the dry and fitting feed continues until

about the time of calving Common salt should be available at all times On deficient areas and when good legume forage is limited a more complete mineral supplement (calcium, phosphorus, and any trace minerals indicated for use by cattle on the local soil area) needs to be provided

Getting the Cow on Feed After calving, a cow is started on a small amount of the regular ration if her condition is good, gauging the amount according to appetite Within ten days she should be consuming at least half of a full grain allowance From this time on the judgment of the feeder and the appetite of the cow determine how much she should receive He will consider the kind and quality of the roughage, as well as the yield and richness of the milk Cows in thin condition may require slightly more grain than those in good flesh The careful herdsman observes closely the character of the dung excreted and learns to judge thereby if the digestion is normal Each animal must receive the individual attention of the herdsman and her characteristics must be understood Use of good roughages must be emphasized

When maximum production is desired, heavy-producing cows often are fed and milked three times per day during the period of heaviest milk flow As a rule, maximum daily milk production will be attained at about four to six weeks after calving A cow cannot be forced to produce milk simply by heavy feeding Overeating may upset the digestive system, and cause the cow to go off feed Such a situation often may be prevented by reducing the daily allowance slightly at the first signs of refusing feed

A good succulent feed such as silage, roots, or pulp is indispensable when high-quality pasture is limited or unavailable A fine-stemmed green leafy hay, often alfalfa, is also desirable During the pasture season the cow may be turned out to graze during the cooler part of the day or night Temporary pasture or a good soiling crop may contribute if the pasture becomes short or dry An abundance of good water should be readily accessible Hot weather is a disturbing factor when high yearly production is desired Cold weather is not harmful so long as animals are in a dry place out of the wind Cows do better in a temperature of 55° F or slightly lower than in a very

hot climate. Free access to cool drinking water and shade in hot weather contribute to the comfort and welfare of animals.

Grain Mixtures for Cows in High Production. A mixture for use by high-producing cows should contain grains or milling by-products representing several different plants. The mixture should be light in character, palatable, and provide an adequate amount of protein. Although individual feeders favor some particular mixture, others have attained equal success with different mixtures. There is no reason to believe that any one mixture is any better than many others that have been used.

Importance of Good Care. High production for a single cow or a whole herd results from a combination of good cattle, adequate feeding, and good management. Milking cows are delicate and intricate factories, producing a highly complex product. Many things may occur that can interfere with this production. Only by a detailed balance and control of all factors may high production be secured.

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though urea and ammonia compounds contribute no energy, the microorganisms in the digestive systems of ruminants do convert them into proteins, and because of their small bulk and the absence of fiber, they are also classed as concentrates.

FODDER

Corn Fodder. The term "corn fodder" indicates that the ears are included. Corn fodder is widely used for wintering beef cattle where hogs are on hand to gather up the corn which would otherwise be wasted. For dairy cows corn fodder is not satisfactory and should be used only to a limited extent, or as a supplement when the roughage supply is short. It is low in protein and relatively unpalatable outside of the grain contained, but it is equal to timothy hay in total nutrients. A limited amount, up to five pounds per head, may be fed to dairy cows. The common plan is to feed it during the day in the open. Cutting or shredding has been recommended to reduce the waste.

Corn Stover. Corn stover is corn fodder from which the ears have been removed. It may be utilized to a limited extent. It is very low in protein, unpalatable, and constipating. The point should not be overlooked, however, that its feeding value is not far behind that of timothy hay. The practice of shredding corn fodder has not been found to increase the feeding value of the stover. The advantage of the treatment is that the stalks are shredded and cut, making it possible to feed the shredded stover in the barn and to use the refuse for bedding. There is also less wasted feed.

Sorghum Fodder. Fodder and stover from the sorghum plant are sometimes cured in shocks in the same manner as that common for corn. The fodder is eaten fairly well during a period of two months after cutting, but it spoils if not properly handled and becomes decidedly unpalatable. Its feeding value is about the same as that of corn products. Cutting or shredding is also recommended for the same reasons as corn.

STRAW

Oat Straw. Oat straw from grain cut rather early will be eaten to a limited extent by dairy cows. It should not be relied upon as an

CHAPTER XXVIII

Characteristics of Common Feeds

Feeds may be divided into two major groups, namely roughages and concentrates Generally, roughages are the leafy and stemmy portions of plants They contain chlorophyl, carotene, reasonable to large amounts of crude fiber, and many minerals, being the major source of calcium in feeds The dry matter of roughages is usually 45 to 60 per cent digestible Roughages are divided further into legumes, grasses, and miscellaneous straws, fodder, hulls, silages, and pasture crops Concentrates are characterized as the seed, fruit, or tuber portions of plants Mainly, concentrates are high in starches and sugars, and are good sources of energy Concentrates are low in fiber, usually high in digestibility, and are fair to good sources of phosphorus and certain other minerals They may be subdivided into the cereal grains, oil seeds, animal by-product feeds, milling by-product feeds, and synthetic nutrients (urea, ammonia compounds, etc) The processed by-products of roots, tubers, and fruits such as dried apple pomace, beet and citrus pulps, are concentrates These often are regarded as bulky concentrates

Milling by-products differ widely in composition, digestibility, and mineral contents, and consequently in feeding value For example, such by-products as cottonseed hulls, ground corncob, oat hulls, etc , being high in fiber, really should be classed as roughages The by-products obtained from the processing of the cereal grains are concentrates, such as corn gluten feed, wheat bran, dried brewers' and distillers' grains Animal by-product feeds are low in fiber, high in digestibility and energy, and belong among the concentrates Al-

molds, or evidences of heating or spoilage. Great differences may be found in the nutrition value of hays cured and handled under different conditions.

Hays and roughages made under modern-day methods are the principal sources of wire and metal hazards for cattle. Great care should be taken that all bits of metal, baling wire, etc., are kept out of the hay mangers as cows will readily pick them up and carry them into the digestive system where they are the cause of many deaths to cattle.

Timothy Hay. Timothy hay is widely grown, largely because it does well almost everywhere and is easy to get started. The value of this hay is greatly overestimated as a feed for dairy cows. It is unpalatable for cows except when cut early and will therefore not be consumed in sufficient quantities. The most serious objection to it is its low protein content, which makes necessary the feeding in larger quantities of concentrates rich in this expensive nutrient when timothy hay is fed. The vitamin A value of timothy hay is often low, especially for the lower grades, and the calcium content is very deficient when grown on acid soils.

Alfalfa Hay. Properly cured hay from the alfalfa plant would easily be ranked first among all hays by dairy cattle feeders. It is very palatable and laxative in character, it contains a relatively large amount of protein, and it is highest of all common feedstuffs in calcium. The best grades also have a high vitamin A, D, and E value. Almost any ration not containing alfalfa is improved by its addition.

Clovers. Clover hay has much the same advantages as alfalfa. It is not quite so palatable, however, and is a little lower in protein. The alsike has practically the same composition as the red but is finer stemmed, making it especially well adapted for calf feed.

Lespedeza Hay. Lespedeza hay, which has essentially the same composition as red clover, is finding increasing use in certain regions. Its feeding value, when the crop is cut in full bloom, is fully as high as red clover hay and nearly equals that of alfalfa, but it is not so palatable.

Sweet Clover Hay. Sweet clover hay also has found wide use in certain regions in recent years. Its nutritive value depends a good

important part of the ration Cows turned out of doors during the winter will eat a little straw if fed in the open It is extremely low in protein, low in total nutrients, and unpalatable In a well-fed herd its only important use is as bedding

Wheat Straw This straw is less valuable than oat straw and is hardly to be counted as a feed at all, but it is excellent bedding material

Rye Straw This straw is useful only as bedding Cattle will not eat it, and the digestible nutrients are so low that it would be useless if eaten

Barley Straw Barley straw has little feed value, and there is danger of the beards penetrating the sides of the mouth and causing trouble

Legume Straw The straw remaining from the threshing of legumes for seed is a better feed than the straw from cereals and, unless too coarse, can replace part of the hay in dairy rations This is especially true for alfalfa, clover, and lespedeza straw

HAY

Hay making in the United States has been revolutionized during the last few years by the use of modern machinery The results have been both good and bad Mechanical methods have taken nearly all the irksome, heavy hand labor out of hay making and reduced the time and hazards of weather to a minimum Field choppers, blowers and mow driers have made great changes in barn structures and in methods of feeding Field balers and loading equipment likewise have taken so much labor out of hay making that loose hay making is almost a thing of the past.

All these changes should make better hay possible and do, but as yet but little good hay is being made Good hays and roughage are essential in cheap and efficient milk production and dairymen should give much more attention to good hay making methods and what constitutes good quality and feeding value in hays

All hays should be cut at an early stage so that the highest per centage of digestible nutrients may be secured All hays should be cured so that they are bright and leafy and free from mustiness

molds, or evidences of heating or spoilage. Great differences may be found in the nutrition value of hays cured and handled under different conditions.

Hays and roughages made under modern-day methods are the principal sources of wire and metal hazards for cattle. Great care should be taken that all bits of metal, baling wire, etc., are kept out of the hay mangers as cows will readily pick them up and carry them into the digestive system where they are the cause of many deaths to cattle.

Timothy Hay. Timothy hay is widely grown, largely because it does well almost everywhere and is easy to get started. The value of this hay is greatly overestimated as a feed for dairy cows. It is unpalatable for cows except when cut early and will therefore not be consumed in sufficient quantities. The most serious objection to it is its low protein content, which makes necessary the feeding in larger quantities of concentrates rich in this expensive nutrient when timothy hay is fed. The vitamin A value of timothy hay is often low, especially for the lower grades, and the calcium content is very deficient when grown on acid soils.

Alfalfa Hay. Properly cured hay from the alfalfa plant would easily be ranked first among all hays by dairy cattle feeders. It is very palatable and laxative in character, it contains a relatively large amount of protein, and it is highest of all common feedstuffs in calcium. The best grades also have a high vitamin A, D, and E value. Almost any ration not containing alfalfa is improved by its addition.

Clovers. Clover hay has much the same advantages as alfalfa. It is not quite so palatable, however, and is a little lower in protein. The alsike has practically the same composition as the red but is finer stemmed, making it especially well adapted for calf feed.

Lespedeza Hay. Lespedeza hay, which has essentially the same composition as red clover, is finding increasing use in certain regions. Its feeding value, when the crop is cut in full bloom, is fully as high as red clover hay and nearly equals that of alfalfa, but it is not so palatable.

Sweet Clover Hay. Sweet clover hay also has found wide use in certain regions in recent years. Its nutritive value depends a good

deal on the time of cutting the crop The fall cutting of the first year and the first cutting of the second year have the highest value, approaching that of alfalfa hay Care must be taken with sweet clover hay because of sweet clover poisoning This poisoning is caused by a mold enzyme which converts the bitter substance "coumarin" in the plant to "decoumarin" This latter substance interferes with the normal process of blood clotting at times of injuries, horn removal, and other operations There is also danger from continuous feeding as sole roughage Intermittent feeding of a week or ten days at two week intervals is recommended to minimize the danger

Soybean Hay This hay has the same advantages and characteristics as other legumes It is very palatable, is high in protein and total nutrients, and also supplies a liberal amount of calcium It is being used in large amounts wherever soybeans can be grown

Cowpea Hay When properly cured, cowpea hay is palatable and even superior to clover in protein and total nutrients It is grown extensively in the southern portion of the United States

SILAGE

The importance of supplying an abundance of succulent feed for dairy cows has been discussed elsewhere Next to good pasture grass there is no better succulence than silage

Silage is made from a great variety of plants in different parts of the United States While corn has been the most universal crop used more recently the use of special preserving materials has made possible and practicable the use of many other crops for silage

Corn Silage In feeding corn silage, it should be kept in mind that corn silage is not of itself a complete ration for the cow in milk, since it is relatively high in carbohydrates and low in protein Furthermore it is not advisable to feed it as the only roughage Some hay should be given as well, and for this purpose the legumes are the best adapted on account of their high protein and ash content It is not advisable to feed over about thirty-five pounds of silage to a small cow and forty to forty-five pounds to a large animal

Kafir Silage Kafir ranks well as a silage crop, being only slightly

behind corn in composition and feeding value. It is widely grown in the semiarid regions.

Sorghum Silage. Common sorghum yields heavily over wide areas and makes a satisfactory silage, ranking, however, somewhat below corn silage. An important point is to allow the crop to reach the proper stage of maturity—otherwise the silage will contain more acid than is desirable.

Pea and Oat Silage. These crops grown together make good silage if cut at the proper stage—when the oats are starting to turn yellow. The protein content is a little higher than that of corn, but the total nutrients are about the same.

Legume Silage. Alfalfa and clover make a satisfactory silage if put into the silo in the proper condition, as described in another chapter. The protein content of legumes is higher than that of corn, and the total of nutrients may be about the same or higher, depending upon the amount of moisture present. Sweet clover may also be used to advantage for silage. The danger of sweet-clover poisoning is not eliminated by ensiling the crop. The chief objection to putting crops of this kind into the silo is the labor involved in handling the green material.

Sunflower Silage. The sunflower thrives in regions where the temperature is too low to develop corn. The yield is large, and the silage is satisfactory succulent feed. Sunflower silage is not equal to that made from corn in the proper stage of maturity, but it is equal in feeding value to silage made from corn in an immature condition. It is not as palatable as corn silage, although cows soon learn to eat it and thrive on a ration containing it. It does not spoil so readily in the summer and therefore has this advantage for summer feeding. It should be cut when the heads are just showing bloom.

Forage Crops for Silage. Many common pasture and forage crops such as alfalfa and brome grass, sudan grass, peas and oats, and heavy-producing pasture mixtures are now being successfully used as silage by the use of a preserving agent. Many different kinds of preservatives are now in common use in different parts of the country. Several different types of acids, sodium metabisulfite, ground

grains such as corn, molasses from beet pulp and blackstrap from cane, as well as hydrol and wood sugar are the most common preserving agents to be used

ROOTS, TUBERS, AND PUMPKINS

Mangels The mangel is the most widely used root crop Like other roots it has a high water content (90 6 per cent), but as a means of supplying succulence it is unexcelled It is highly palatable and except for high labor costs should be fed more generally in this country—as it now is in Europe Forty to sixty pounds a day is a fair allowance

Rutabagas This crop has the same advantages as mangels, and practically the same feed value As with other turnips, there is some danger of the milk being tainted when it is fed

Sugar Beets The sugar beet is not generally grown for feeding as the yield is lower than for mangels or rutabagas and the labor of raising is greater As a palatable succulent feed, sugar beets are highly prized Because of the high sugar content, the feeding value of sugar beets is somewhat more than of mangels or rutabagas

Beet tops are a valuable feed, and where beets are grown for market, the tops should be preserved for feeding This is best done by putting them in a silo The dry matter of beet tops is rich in calcium, but it is not commonly recognized that at least three fourths of the calcium is present as calcium oxalate from which the calcium is not available

Potatoes Cull potatoes are at times available in sufficient quantities to justify considering their use as feed The potato contains about double the dry matter content of roots but is not as desirable a feed for the bovine Potatoes are best fed to swine, but they may be used up to twenty five pounds daily for feeding cows Large amounts have a detrimental effect upon the quality of butter produced and are liable to cause indigestion in the animals

Pumpkins Pumpkins are often planted with corn and provide an excellent supplement to the ration for a period in the fall, when pastures may be short The feeding value of the pumpkin is not high and they should be looked upon as a relish than as a main part

of the ration. The pumpkin is over 90 per cent water and about 2½ tons, including seeds, are required to equal a ton of corn silage in feeding value. The seeds are sometimes removed when feeding pumpkins because of the erroneous idea that they dry up the cows. There is no ground for this belief, as the seeds are rich in feed nutrients and contain no injurious substances.

CONCENTRATES

Almost all concentrates used in dairy cattle feeding are the common farm-grown grains such as corn, oats, wheat, rye, barley, and sorghum grains.

They are best used when ground and mixed with other higher protein concentrates such as the by-products of the milling, vegetable oil, and distilling industries. Where a power mixer is used it is well to have it equipped with an electromagnet to remove all bits of wire and other metal objects.

Corn. Over the greater part of America, corn is the most common and the cheapest grain. In the corn belt this valuable grain is often fed to excess. On the other hand, some dairymen avoid feeding it altogether, on account of an erroneous idea that it is not suited to a cow producing milk. Corn may be fed in reasonable quantities to any class of animals on the farm. It is especially palatable to the cow in milk. However, for good results, it must not be the exclusive grain ration. The protein quality of corn is poor and the content low Likewise the mineral content is low, especially the calcium. If combined with corn stover or corn silage for roughage, the protein content is entirely too low for a dairy ration. Corn silage and ground corn combined with clover or alfalfa hay and bran, however, make a good ration for general feeding.

Wheat Bran. Next to corn, wheat bran is one of the most important cow feeds of this country. Its great value as a food for growing animals and cows in milk comes, in large part, from the high phosphorus and protein content. Its light, loose character also makes it a valuable addition to a heavy ration in the way of lightening up the mass to make it more easily acted upon by the digestive juices.

Wheat Middlings. Standard wheat middlings, or shorts, are val-

uable feed for the cow, and resemble bran in general properties although not as bulky In composition, the middlings average higher in protein and digestible nutrients than do wheat bran but lower in calcium and phosphorus As a rule, bran is more widely used at the present time than shorts for the cow in milk

Oats and Oat Products Oats are a fine feed for cows and growing animals when the cost is not prohibitive Woll found oats to be about 10 per cent more valuable pound per pound than bran when fed to cows In general, it may be said that oats are an excellent ration, but they do not contain sufficient protein to be as effective in supplying a deficiency in that respect as are other feeds with a higher protein content The valuable by products of oats are mainly from oatmeal mills, and consist of oat shorts and finely divided parts of the grain sifted out In addition, a large quantity of hulls must be disposed of by these mills Hulls are mostly crude fiber and are hardly equal to the same weight of timothy hay in feeding value The by-products of the oatmeal mills are therefore valuable to the extent that they contain the parts of the grains Oat hulls are used largely to form a portion of various mixed feeds

Barley Barley is an important dairy feed in Europe In America, corn, on account of its abundance and cheapness, has taken its place In composition and feeding value, barley is practically equal pound for pound to corn Ground barley as the sole grain has been reported as causing bloat It would seem best to employ it only as a part of a grain concentrate mixture

Rye Rye has a composition not greatly different from corn, but it ranks somewhat below corn in results It is unpalatable, and when fed in large quantities tends to cause a butter with a hard objectionable body It can be fed up to two or three pounds a day by being ground and mixed with other grains

BY PRODUCTS

Much of the high protein concentrates today used in dairy cattle feeding come as by products of the vegetable oil industries In these industries three different principal types of oil production are commonly used They are the older hydraulic methods, the solvent proc-

esses, and the more recent expeller methods. The meal by-products, therefore, will vary somewhat in composition and value but are all highly valuable dairy feeds.

Cottonseed Meal and Cake. This by-product is the residue left after the oil is pressed out of the cooked or crushed cottonseed kernels. It contains as high an amount of protein as any concentrated feed ordinarily found upon the market. It is also rich in phosphorus. For these reasons, it is especially valuable as a means of balancing up rations deficient in protein and phosphorus. It should not be fed to excess at any time. Dairymen have considered four pounds per day as the maximum to be used. However, in the South, where it is abundant, it is fed in much larger quantities, with good results. Cottonseed meal should always be fed with good roughage which is of high vitamin A value and carries adequate calcium. So-called cottonseed meal poisoning in cattle is largely vitamin A deficiency due to improper use of the product. If it is desired to buy cottonseed meal in large quantities and to store it for some time, especially over summer when it may become rancid, it is best to buy it in the cake form or preferably broken into pieces, but not ground. The cakes grind easily and may be ground as needed.

Soybean Oil Meal. This product results from the removal of the oil from soybeans. Of three common processes—i.e., hydraulic pressure on cooked beans, extraction by a solvent, or a continuous expeller process which generates considerable heat—the latter is increasing in favor in production of high-protein meal of highest nutritive value because a certain amount of heat seems to be essential to confer the best quality on the bean proteins. Some mills are subjecting the solvent-process meal to a toasting to secure the same result. Soybean oil meals compare with the cottonseed meals in protein. They are not high in calcium and contain about 60 per cent as much phosphorus as cottonseed meal. This by-product protein concentrate seems destined to find increasing use in the dairy ration.

Linseed Meal. This valuable feed is the residue after the linseed oil is extracted or pressed from flaxseed. It ranks next to cottonseed meal and soybean meal in protein, but on the market it usually sells a little higher. It seems to have a specially favorable effect upon all

kinds of animals to which it is fed Like cottonseed meal, it is especially valuable as a means of supplying the protein and phosphorus likely to be lacking in the farm grown ration It is higher than soybean meal in both calcium and phosphorus It is somewhat laxative in character

Peanut Meal In the south where peanuts are a major crop and many peanuts are processed for oil and peanut products, peanut meal is a valuable dairy concentrate It varies in its composition more than most other oil by products and may become rancid in storage or in warm weather It is verv palatable and somewhat laxative Peanut feed meal is a less valuable feed as it contains a larger amount of high fiber ground peanut shells

Corn Gluten Meal This is a by product of starch and glucose manufacture The bran or outer layer of the corn, the germ, and most of the starch are removed in the process of manufacture, leaving a residue which is mostly the protein of the kernel Corn gluten meal ranks high in digestible protein, but it is a heavy, rather unpalatable feed and should always be fed in a mixture with other feeds of a more bulky character The protein content varies considerably, and the guaranteed analysis of the meal should always be taken into account when it is bought

Gluten Feed Gluten feed or corn gluten feed is gluten meal with the corn bran added It is high in protein although lower than gluten meal and on account of the bran it is bulkier and safer to feed It is fed more generally than the corn gluten meal Gluten feed is a valuable and at times an economical source of protein but it is not advisable to use either gluten feed or gluten meal as the sole supplement to a corn ration

Brewers' Grains Fresh brewers' grains were fed in large quantities in the early days of dairying in localities where they could be hauled directly from the brewery Considerable objection was raised by city health authorities in many places to the use of this feed so that the use as a wet feed direct from the breweries has greatly declined If fed in moderate amounts under proper sanitary conditions they are not objectionable However, the use of them is so often abused that some officials have found it easier to prohibit than

to regulate it. The objection comes from their being fed exclusively, from their being allowed to begin decomposing before they are fed, and from the very objectionable sanitary condition that exists if special care is not taken to keep the feed boxes, feeding troughs—in fact, the entire stable—clean. This feed should not be used in excess of 20 pounds per day, and it should be supplemented with hay and some other grain, such as corn.

The greater part of the brewer's grains are now dried, and in this form are a valuable feed. This feed is bulky and palatable. Dried brewers' grains may be obtained having a digestible protein content of 21.5 per cent—more than twice that of oats—with a content of total nutrients slightly below that of oats.

Distillers' Grains. Distillers' grains are by-products of the manufacture of alcohol and distilled liquors from corn, rye, and at times, some mixture of rice and other cereals. This feed does not rank with corn gluten meal in protein content. Like the other by-products of this class, it varies greatly in protein, and the buyer should take as a guide the guaranteed analysis. Distillers' grains are rather unpalatable, but they are eaten without trouble when fed in a mixture with other feeds. The advisability of making use of this class of feed will depend mostly upon the market value.

Dried Beet Pulp. Since the beet sugar industry has become of some importance in the United States, the by-products are found on the market for cattle feed. The wet beet pulp from the factory contains only about 10 per cent of dry matter and has been much used around beet sugar sections. On account of its bulk it cannot be transported any distance, and it is fed only in the immediate neighborhood of the factory. Most of the beet pulp is now placed on the market in the dried condition, in which form it has met with considerable favor as a feed. Beet pulp is high in carbohydrates in proportion to protein, ranking in this respect below corn. In feeding it should be combined with other feeds richer in protein. It swells when moistened, and cannot be pressed into a compact mass. For this reason it is easy to digest and valuable to lighten up a grain ration that otherwise would form a mass in the stomach not easily penetrated by the digestive juices. It is especially useful in feeding cows for the maximum

production, as under official test conditions The dried beet pulp is usually moistened with about three times its weight of warm water, several hours before feeding The grain mixture is either mixed with it or spread over it in the feed box

Dried Citrus Pulp Dried citrus pulp is a product of the citrus industry It is produced as a by-product of citrus concentrate such as orange juice It is produced in five southern states and is coming into general acceptance and favor as a bulky carbohydrate concentrate where produced and is being shipped elsewhere

MOLASSES AND MIXED FEEDS

Molasses There are five different kinds of molasses commercially on the market for use as dairy feeds They are blackstrap from sugar cane, molasses from sugar beets and citrus, hydrol, and wood sugar molasses They are similar as sources of carbohydrate, which is their principal food value Blackstrap is a byproduct of the cane sugar factories and is the one most generally used Blackstrap has about 75 per cent of the feeding value of corn, pound for pound It is practically a pure carbohydrate mixed with a certain amount of mineral matter It may take the place of other carbohydrates such as corn whenever the price is comparable Molasses serves a useful purpose as a means of making unpalatable feeds more readily consumed Unfortunately, on account of its palatability it is too often used to cover up inferior quality in a mixed feed or to disguise materials of little feeding value Molasses serves a useful purpose as an appetizer for animals receiving a heavy ration and is used by many feeders of cows in heavy production As a source of digestible nutrients it is usually too expensive for general feeding

Mixed Feeds No small proportion of the grain fed the dairy cows of the United States is in the form of ready mixed feeds In the past, mixed feeds were in bad repute because of the common practice by unscrupulous manufacturers of using this means to dispose of inferior or worthless products As a result in most of the states where considerable quantities of mixed feeds are sold, laws are now in force which require the labeling of each sack with a guaranteed analysis and a registration with state authorities of the ingredients present

which are available to the buyer. Some provision is made for inspection by state authorities to insure the feed being as represented by the label. Many reliable companies are now engaged in the business of preparing mixed feeds. By patronizing firms of known repute and paying proper attention to the guaranteed analysis, the buyer may use feeds of this class with advantage.

Where only a few cows are to be fed, it is often impracticable to have several kinds of feeds on hand from which to prepare a mixture, as often the kinds needed are not for sale locally. The feeder may be uncertain as to proper combination. Under these conditions a ready mixed feed serves the purpose to advantage, making it possible to supply the necessary variety and at the same time to purchase limited quantities at a time. When large quantities of feed are purchased, there is little advantage in buying it in mixed form. The person who has the responsibility for the feeding of the herd under these conditions should have the knowledge and mixing equipment necessary to prepare a suitable mixture; and unmixed grains and by-products are usually cheaper sources of nutrients than the mixed feeds.

Under present conditions the former objection of inferior quality in mixed feeds has largely disappeared. The main question that is now being raised is that of economy. The retail price of mixed feeds generally includes more transportation charges than are necessary on unmixed grains or by-products. The ingredients may be shipped from several states to the point where the mixing is done. The mixed feed is often shipped back to the same region from which the products included came originally, making a second freight charge necessary. As a rule, the retailer also receives a larger margin of profit on the mixed feeds that sell under a special brand.

Unlike unmixed grains, which need no advertising, the expenditure of large sums is necessary in order to familiarize the public with a particular brand. This expense is necessarily added to the selling price.

BUYING FEED BY ANALYSIS

As already mentioned, nearly all states in which large quantities of feed are purchased by the farmers now have some law in force

regarding the sale of feeding stuffs These laws, however, do not take the place of intelligence on the part of the feed users Such laws generally require the proper branding and labeling of each sack to indicate the chemical composition It should be remembered that the label gives the total amount of protein and other constituents, not the amount that is digestible, which will be decidedly lower Every feed buyer should patronize only reliable dealers, and buy feeds that are labeled and guaranteed There are no mixtures better than the buyer can make himself, and there is no special feed or mixture having any remarkable properties not possessed by familiar feeds The buyer of mill feeds should make a point of keeping in touch with the experiment station of his state—and if the feed control is vested in some other body or official, with them as well—and make use of the information they will be able to furnish regarding the feeds on the market

ALFALFA MOLASSES FEEDS

In recent years a large number of feeds have been placed on the market which are chiefly ground alfalfa and blackstrap molasses In some cases a small amount of ground grains or by-products are also included These feeds, when put out by reliable firms insuring a good quality of alfalfa meal and other ingredients, are a useful addition to the available feedstuffs Cattle eat such feeds with great relish, and the results are satisfactory The chief objection is that the price at which feeds of this class are sold is usually such that they cannot be used with economy Adding a small quantity of molasses to hay does not justify prices equal to those of grains Unfortunately, many preparations of this kind, in addition to being an expensive source of feed nutrients are made from alfalfa meal of such inferior quality that animals would not eat it at all were it fed without molasses In some cases damaged hay, or even alfalfa straw, is used, and damaged grains, mill sweepings, or oat hulls from an oatmeal factory are added to give the appearance of grains in the feed

STOCK FOODS

Through the force of advertising, the farmers of the country have been led to spend millions of dollars for foods of this kind Stock

foods or condition powders usually consist of a mixture of common feeds such as linseed meal, wheat middlings with some common substances, such as common salt, charcoal, Epsom salt, ginger, gentian, and copperas. These are generally harmless, but are worth no more to the animal than an equal amount of ordinary feed. Some have been found to contain as high as 70 per cent common salt. The stockman should not waste his money by investing in this class of feeds. If his animals are in good condition they need no tonics; if sick, they need the specific treatment of a well-qualified veterinarian, not a cure-all in the form of a mixture of substances unknown to the user.

GROWTH STIMULANTS AND ANTIBIOTICS

With monogastric animals and fowls, certain antibiotics have given some added growth stimulus on slightly poor rations. These species depend little on symbiotic microorganisms for their welfare. Calves are virtually monogastric animals at birth and for a few days thereafter.

A subcommittee of the National Research Council surveyed investigations in this field and concluded that dairy calves had responded either favorably or not at all to low levels of several antibiotics. Penicillin and chloromycetin depressed appetite and increased occurrence of scours in some cases. Aureomycin and terramycin gave some early growth stimulus, improved appetite and fewer cases of scours occurred when fed during the first four months. Accelerated growth ceased on withdrawal of the antibiotic. In general, the period of accelerated growth is of short duration. Some studies indicate depressed cellulose digestion when aureomycin or terramycin was in the feed. There is some evidence of interference of aureomycin, bacitracin, penicillin, and terramycin with utilization of urea and ammonia compounds by rumen microorganisms.[1] Possibly there is some change also in synthesis of water-soluble vitamins. Results indicate that if antibiotics are used with cattle, they should be given only to young calves.

[1] Prescott, "Rumen microorganisms. Effect of diet and antibiotics on utilization of non protein nitrogen." *Journal Agricultural and Food Chemistry*, 1:894–896 (1952).

CHAPTER XXIX

The Feeding Standard and the Calculation of Rations

The Requirement of an Animal A dairy cow uses feed for the following purposes

1 *For maintaining the body*
2 To supply material for milk
3 For development of the fetus
4 For growth in case the animal is immature
5 At times to produce gain in weight
6 To perform work in grazing and exercise

For each of these purposes the following classes of food material are required

1 Proteins.
2 Carbohydrates and fat.
3 Mineral matter
4 Vitamins.

The information available concerning the vitamin requirements for cattle is of recent development and by no means complete Much research is still being done in this field as well as in the new field of hormones The main problem of feeding is to supply the proper amount of the food material of the above four classes in the least expensive form It is evident that the first step is to know what the animal requires for food and how to prepare a ration that will meet this demand

Composition of Feeds. When a chemist makes an analysis of any feedstuff—clover hay, for example—he determines the amount of water, proteins, ash, crude fiber, and fat contained in the substance. The remainder of the feedstuff is referred to as nitrogen-free extract, and is calculated by difference.

Water. All feeds—even those apparently dry, like corn or hay—contain a portion of water varying from 10 to 15 per cent. Roots, such as beets and turnips, contain approximately 90 per cent water. The water in the feed serves the same purpose as ordinary water consumed by the animals.

Ash. This is the mineral part of the food substance remaining after the material is burned. It contains most of the mineral elements which comprise a necessary part of every ration.

Proteins. These important constituents are characterized by the fact that they contain nitrogen. They serve the purpose of building up tissue in the body—such as muscle, skin, etc.—and constitute the main element in the curd of milk. Lean meat and the white of an egg are familiar examples of nearly pure protein material. All feeds contain more or less proteins. Among the hays, clover, alfalfa, cowpea, and soybean contain the largest amount. Among the common concentrates, linseed meal, cottonseed meal, and wheat bran contain relatively large quantities. A certain amount of proteins is indispensable in a ration, as nothing else can be completely substituted for them by the animal.

Crude fiber. There are two types of crude fiber, the lignified and nonlignified. The lignified type is found in mature roughages and reduces the digestibility and feeding value of the roughage. The nonlignified type is found in young grass and root crops. This type is much more highly digestible and nutritious.

Nitrogen-free extract. This is a term given to all the substances in a feedstuff not determined by direct analysis, such as water, protein, ash, fiber, and fat. The greater part of the nitrogen-free extract is starch.

Fat or ether extract. That part of the feedstuff which will dissolve out in ether is called an "ether extract." It consists mostly of fats

The digestible crude fiber, nitrogen-free extract, and fat all serve

much the same purpose in the body They supply heat to keep the body warm, material to be built into fat and to be burned or oxidized in the body to furnish energy A certain amount of fat in the feed is required for satisfactory milk production All feedstuffs contain these same constituents, but in widely varying quantities

Digestibility The animal is not able to digest all the substances in any feedstuff The proportion of the protein, for example, that may be used depends largely upon the nature of the feed under consideration, the grains being more thoroughly digested than the hays The amount of each of the substances given that can be digested from any feedstuff by the animal is determined by what are termed *digestion trials* The chemist makes such a trial by analyzing the food consumed during a certain period by an animal, and at the same time collecting all the dung and analyzing it to find out how much passes through the alimentary canal The difference between the amount consumed and the amount voided is called *digestible* Such tests have been made of all common feeding stuffs, so the practical feeder has data at hand regarding both the normal composition of feeds and their digestibility to serve as a guide in preparing suitable rations

The Feeding Standards Numerous chemical analyses have been made of all common feedstuffs These data show how much of the several constituents will be supplied by feeds of average composition It is known that the animal needs all these constituents The question is, how much is needed for a particular purpose, as for maintenance, growth by the immature animal or for milk production by the cow This problem has received the attention of numerous investigators for many years The conclusions from such investigations, setting forth the nutrient needs of an animal for certain purposes, are called feeding standards

Digestible nutrients theory The history of the development of feeding standards is a long one and will not be given except in brief The standard published originally by Wolff, and later known in the revised form as the Wolff-Lehman, became most widely known, although later standards have been more suitable for the ordinary feeder In this standard the requirements of the animal and the nutritive value of feeds are given in terms of digestible proteins,

digestible carbohydrates, and digestible fat or ether extract. The digestible carbohydrates include the digestible crude fiber and the nitrogen-free extract.

The early standard formulated by Haecker[1] has been widely used in America. The feed requirements in this standard are expressed in the same terms as the Wolff-Lehman. It was a decided step in advance, however, in so far as provision was first made for the maintenance of the animal and then an allowance added according to both the amount and the richness of the milk produced.

Net energy. Kellner in Europe and Armsby in the United States materially advanced the fundamental knowledge of nutrition. Armsby[2] also formulated a feeding standard based upon his investigations. In his system the requirements of the animal and the value of the feeds are expressed in terms of protein and net energy. The term "net energy" represents the heat-producing value of the feed which the animal actually uses for productive purposes. The Armsby method gives the most exact statement of productive feed values. His view that only intact proteins are used by the animal is not generally accepted and stands in the way of a more general use of his feeding standard.

More recently, Morrison has suggested a standard which he described as a modification of the Wolff-Lehman. This standard makes use of the most valuable features of the Wolff-Lehman and the Haecker standards and also embodies some further improvements.

Total digestible nutrients. In this standard the requirements are given in terms of "digestible crude protein" and "total digestible nutrients." The total digestible nutrients are the sum of the digestible proteins, the digestible carbohydrates, and the digestible fat multiplied by the factor 2.25. The factor 2.25 is used to convert the fat into its equivalent carbohydrate value. The requirement for the cow is divided into two parts, that used for maintenance, and that necessary for milk production, taking into account the amount and richness of the milk. Table 59 gives the Morrison standard.

[1] Haecker, Minnesota Agricultural Experiment Station Bulletin 130 (1913), 9th (last) edition (1921).

[2] Armsby, *The Nutrition of Farm Animals*, pp. 714–721. The Macmillan Co., New York (1917).

Table 59 Morrison Feeding Standard for Milk Production (Condensed)*

DAIRY COWS	DIGESTIBLE PROTEIN†	TOTAL DIGESTIBLE NUTRIENTS†	CALCIUM		PHOSPHORUS		CAROTENE	NET ENERGY†
	Lbs.	Lbs	Grams	Lb	Grams	Lb	Mg	Therms
A For maintenance per head daily								
800 lb cow	49- 54	5 8-6 5	8 0	018	8 0	018	48	4 6-5 2
1000 lb cow	60- 65	7 0-7 9	10 0	022	10 0	022	60	5 6-6 3
1200 lb cow	70- 76	8 2-9 3	12 0	026	12 0	026	72	6 6-7 4
1400 lb cow	80- 87	9 4-10 6	14 0	031	14 0	031	84	7 5-8 5
1600 lb cow	90- 98	10 5-11 6	16 0	035	16 0	035	96	8 4-9 6
1800 lb cow	1 00-1 08	11 7-13 2	18 0	040	18 0	040	108	9 3 10 6
B For milk production per pound milk (To be added to allowance for maintenance)								
For 3 0% milk	036- 043	26- 28	1 0	0022	75	0017	—	24- 26
For 3 5% milk	038- 046	28- 30	1 0	0022	75	0017	—	26- 28
For 4 0% milk	041 049	31- 32	1 0	0022	75	0017	—	29- 30
For 4 5% milk	044- 052	33- 35	1 0	0022	75	0017	—	31- 32
For 5 0% milk	046- 052	35- 37	1 0	0022	75	0017	—	33- 35
C Additional allowance for last 2 3 months of pregnancy (To be added to allowance for maintenance and milk produced.)								
Small cows	50- 55	5 0-5 5	10 4	023	6 4	014	24	43- 47
1000 lb cows	50- 60	5 0-6 0	13 0	029	8 0	018	30	47- 51
Large cows	65- 70	6 5-7 0	15 6	034	9 6	021	36	55- 60

* By special permission of Morrison Publishing Company Ithaca New York. From *Feeds and Feeding* 21st Ed. by F B Morrison (1948)

† Lower amounts minimum advised Higher amounts advised under usual conditions.

National Research Council Standard This standard was developed by a special committee of specialists in dairy cattle nutrition and was first published in 1945 It takes into account all the more recent research in nutrition, especially in the important fields of minerals and vitamins It is frequently revised as new research develops new information The revised standard is found in the index and is discussed in some greater detail in the chapter on "Nutrition"

Calculating a Ration The use of the feeding standards is best illustrated by examples such as are met in practical feeding Assume that a Holstein cow weighing 1,250 pounds is producing forty pounds of milk daily, and testing 3 5 per cent of fat The requirements for

this cow according to the Morrison standard as given in Table 59 are as follows:

	DIGESTIBLE PROTEIN LBS.	TOTAL DIGESTIBLE NUTRIENTS LBS.
Maintenance, 1,250 lbs.	0 790	9 64
Milk, 40 lbs , 3.5 per cent fat	1 840	12 00
Total	2.630	21 64

In obtaining these figures the first step is to calculate the maintenance. Table 59 gives the figures for a 1,000-pound animal. The amount needed for a 1,250-pound cow may be calculated by proportion or by finding the amount required for a hundred pounds and multiplying this by 12.5. The nutrients needed for one pound of milk with 3.5 per cent of fat are found from the same table, and the amount calculated for forty pounds.

The next question is to find a ration that supplies the nutrients as needed according to the calculations made. In calculating the ration, the suggestions previously made concerning the use of a succulent feed and a legume hay will be followed in selecting the roughage. A cow when fed all the corn silage and alfalfa hay she will eat takes thirty to forty pounds of silage daily, depending upon her size, and from ten to twelve pounds of hay per 1,000 pounds of weight. The practical rule of allowing one pound of grain for four pounds of milk produced by a Holstein cow will be followed in making the first calculation.

PROPOSED RATION	LBS	DIGESTIBLE PROTEIN LBS.	TOTAL DIGESTIBLE NUTRIENTS LBS.
Corn silage	40	0 440	7 08
Alfalfa hay	12	1 166	5 68
Corn	4	0 276	3 35
Oats	4	0 376	2 80
Oil meal	2	0 604	1 56
Total		2 86	20 47

This ration, as calculated, is a little higher in protein and a little low in total digestible nutrients. The addition of a pound and a half of

corn to the ration would bring the total to 2 96 pounds of protein and 21 72 pounds of total nutrients, which is sufficiently close for practical use

Deficiencies of a Ration Shown by the Feeding Standard One of the most effective means of showing deficiencies in rations as fed under practical conditions, is to calculate what the cow is receiving and how near the ration comes to meeting the requirements, or how much milk she could produce from the ration received, and what the limiting factor is

For example, in the corn belt states, a common ration is corn fodder or corn, timothy hay, corn and oats Assuming that a ration of this kind is fed a Guernsey cow weighing 1,000 pounds, how much milk is it possible for her to produce and what is the limiting factor?

On account of the unpalatable nature of the roughage, even under the best conditions a cow will not usually eat over ten pounds each of the timothy hay and corn fodder We will assume that the animal also receives eight pounds of a mixture of equal parts corn and oats This ration would supply the following

	LBS	DIGESTIBLE PROTEIN LBS	TOTAL DIGESTIBLE NUTRIENTS LBS
Corn fodder	10	0 380	5 88
Timothy hay	10	0 290	4 89
Corn	4	0 264	3 20
Oats	4	0 376	2 80
Total		1 310	16 97

A 1,000 pound cow would require for maintenance 0 650 of a pound protein and 7 93 pounds total nutrients

The situation regarding the nutrients received by the cow is as follows

	DIGESTIBLE PROTEIN LBS	TOTAL DIGESTIBLE NUTRIENTS LBS
Received in ration	1 310	16 97
Maintenance 1,000 lbs	0 65	7 92
Available for milk	0 660	9 05

According to the standard, milk with 5 per cent of fat requires 0.056 of a pound of protein and 0.373 of a pound of total nutrients for each pound produced. The protein available in the ration given is sufficient for 11.7 pounds of milk. No cow receiving a ration of this kind can be condemned for not producing a liberal flow of milk. While this ration is open to criticism on several points, the most serious is its great deficiency in protein. This will limit production. The ration could be greatly improved by the substitution of two pounds of linseed oil meal for the same amount of either corn or oats, as there are enough total digestible nutrients for about twenty pounds of milk if the protein deficiency is supplied.

While this elementary example does not take into account the requirements for either minerals or vitamins as it should in actual feeding, a quick comparison of this ration with the standard prepared by the National Research Council for Vitamins and Minerals will show its deficiencies in these necessary elements also.

Value of Feeding Standards. The use of the feeding standard serves as an excellent general guide for the selection of rations. When the use of the standard is fully understood, occasional calculations will generally be made—for example, when making plans for the winter feeding. Practical feeders who make use of feeding standards do not undertake to calculate rations for each cow, but for typical animals of the herd. The greatest value in such a calculation is to assure adequate supplies of all needed elements at the lowest cost.

However, too few practical feeders really make use of feeding standards, although a closer use of such standards would put many dollars in their pockets. Even extension specialists and county agents in rendering assistance to the owners of dairy herds seldom use the feeding standards as they should in undertaking to improve the feeding systems found in use. The student, however, should master the subject, and the knowledge gained will serve as a basis for a sound understanding of the whole subject of proper feeding practices.

In addition to the difficulty encountered by the inexperienced in working out the details of a ration, several other facts tend to give the feeding standard a less prominent position than it deserves. One is that it is at times not economical to follow the feeding standard. For

example, an abundance of home-grown corn and oats may be on hand and cheap in price, while high protein concentrates like linseed meal are unusually high in price A farm-grown ration with corn and oats supplying the grain will be too low in protein if the proper amount of total nutrients is fed In such a case the economical thing to do at times is to feed more total nutrients than are really needed in order to get enough protein, thereby avoiding the necessity of buying the high priced concentrates

In certain regions the reverse condition exists, and the ration available supplies too much protein in proportion to the total nutrients needed Frequently it is economy under these conditions to overfeed in protein in order to supply the necessary total nutrients For these reasons much practical judgment must be always used in developing the best feeding practices

Succulence. In the past, succulence was supposed to be some dietary factor found in green grass and certain feeds This has been found in reality to be largely, if not wholly, the question of sufficient water or the water content of such feeds In the early days of feeding standards it was thought that the total digestible nutrients of timothy hay were not equal to the same total digestible nutrients in corn silage This difference was attributed to succulence, when in reality it was not due so much to the difference in succulence as to the influence of dietary factors furnished by the corn grain in the silage

The feeding standards also take no account of palatability, or variations in quality Coarse or rain bleached hay, having practically the same chemical composition as hay of good quality, would rank as having the same value in such calculations Experience shows there is a wide variation in feeding value in a case of this kind

The great importance of supplying adequate amounts of minerals is now recognized It is certain that, at times, high-producing dairy cows either suffer from lack of calcium, phosphorus, or other minerals, or are dangerously close to the line The wide acceptance and use of the standards developed by the National Research Council bear this out.

It has been found in recent years that the quality as well as the quantity of the proteins is important. The feeding standards and the methods of valuing feedstuffs used in their application as yet do not take this important fact into account.

Investigations in animal nutrition have revealed the fact that vitamins are also indispensable for the growth and well-being of animals. Up to the present, some fifteen vitamins have been discovered—all of which have important functions. Most of the knowledge of these substances has been obtained from experiments with small animals, such as rats and guinea-pigs; too few investigations have been made regarding the vitamin requirements of cattle. It is certain, however, that the cow also requires a number of these vitamins. Much research in the field of vitamins is still needed.

Determining the Cost of Nutrients. When feed is to be purchased, the question at once arises as to which of those available supplies the most for the cost price. A farmer having clover hay, corn silage, and corn on hand, for example, realizes that a high protein concentrate is needed—otherwise the protein will be too low. Again it may be a question involving the purchase of the entire grain ration and total nutrients as well as protein. As pointed out, the animal needs a certain amount of total nutrients, included in which must be enough protein to meet the needs. It is clearly impossible to express the value of a certain feed in a single term since high protein feeds also supply other digestible nutrients as well, and feed low in protein—like corn—used primarily *for their total nutrients* also supplies some protein. For these reasons it should be clearly understood that considerable judgment has to be exercised in interpreting the results.

However, information of value in deciding which feed is to be purchased can be obtained by calculating the cost of a pound of digestible protein or of total nutrients from the cost of the feed and the composition. For example, if the buyer needs protein to supplement this home-grown ration, it is easy to determine in which of the feeds offered it may be obtained the cheapest.

Suppose that wheat bran may be obtained at $40 a ton, linseed

meal at $80, and cottonseed meal at $70 Which is the cheapest source of protein? A calculation should be made as given below

FEED	PRICE PER 100 LBS	DIGESTIBLE PROTEIN IN 100 LBS	COST OF 1 LB PROTEIN
		Lbs	Cts
Bran	$2 00	12 5	16 00
Linseed meal	4 00	30 2	13 24
Cottonseed meal	3 50	37 0	9 46

The figures show that at the prices given, cottonseed meal is the cheapest source of protein, and bran the most expensive

The same procedure may be used to show which feed supplies total digestible nutrients at the least cost For example, corn is worth $1 00 a bushel, oats 75 cents, and barley $1 50, and the question is which furnishes the most for the price The calculation would be as follows

FEED	PRICE PER 100 LBS	DIGESTIBLE NUTRIENTS IN 100 LBS	COST OF 1 LB DIGESTIBLE NUTRIENTS
		Lbs	Cts
Corn	$1 79	80 6	2 22
Oats	2 34	71 5	3 27
Barley	2 50	78 7	3 18

This calculation shows that at the prices given, a pound of digestible nutrients can be purchased at the least expense in the form of corn

The Balanced Ration. The term "balanced ration" has been widely used in connection with feeding standards So used, it has referred to a proper proportion, or balance, between the protein on one side and the carbohydrates and fat on the other The proper proportion depends on the needs of the particular animal being fed Along with this usage also came the term "nutritive ratio" The nutritive ratio is found by adding together the digestible carbohydrates and the fat multiplied by 2 25, and then dividing the sum

by the digestible protein. The result is expressed as a *ratio* in which the protein is 1. The nutritive ratio of corn, for example, is 1 to 10.4.

These terms are not as generally used as formerly. They no longer are adequate to cover all that is required in the consideration of a balanced ration. The test of the adequacy of the ration is its successful use over a period of months with the class of livestock for which it is intended.

CHAPTER XXX

The Silo and Silage

History. The practice of preserving feed in an airtight receptacle is by no means new As far back as the Roman Empire, grain and green feed were preserved in underground pits making use of the same principle as that used in preserving silage in the modern silo As early as 1780, green feed for cattle was preserved in pits and casks in Italy The first published account of preserving corn by means of a silo dates back to 1869 The first book on silage was written by Goffart, in France, in 1877 The first silo in America was built by Miles, in Michigan, in 1875 About the same time Morris, of Maryland, attracted attention by reporting his experiments along the same line The first silos used in America were square structures usually built in the barn The round silo came into use as the result of the very important work of King,[1] of Wisconsin, the results of which were published from 1892 to 1895 In 1882, less than 100 silos were in use in America Some interest in silos was aroused between 1885 and 1895 as the result of experimental work. The interest, however, was not general on account of the cheapness of feed and the inefficiency of the square type of silo used Silos developed to their greatest popularity from 1910 to 1925 In 1950 the U S Department of Agriculture reported 679,746 in use

Advantages of the Silos There are a number of advantages that go with the use of the silo, but the greatest of all is the possibility it affords of utilizing all the crop This is especially true of corn, which is the main crop used for silage When corn is husked in the ordinary

[1] Wisconsin Agricultural Experiment Station Bulletin 28 (1891)

way and the fodder left in the field, from 60 to 70 per cent of the food value of the corn crop is taken with the ears, while from 30 to 40 per cent remains with the fodder. When the silo is used, all the feeding value goes into the silo and the loss in feeding value is about 8 per cent, leaving 92 per cent of the feeding value of the crop as it stood in the field.

The amount of this saving is easily understood by making comparisons with timothy hay. A ton of timothy hay contains 938 pounds of digestible nutrients. If an acre of corn yielding 50 bushels is put into the silo, an additional 854 pounds of nutrients are saved above the value of the grain. This additional saving would be equivalent to 1,820 pounds of timothy hay an acre. At $15 a ton for hay, the nutrients saved by the silo would be equal to $13.65 an acre.

Saving of room. Another distinct advantage of the silo is the large amount of feed that can be stored in a given space. A ton of silage can be stored in 50 cubic feet of space, while a ton of hay requires 400 cubic feet.

Convenience. With present mechanical equipment, the ability to get feed in from the fields with the minimum of labor when the weather is good, and the satisfaction of feeding from a central and convenient source when the weather is bad, are two of the great values of a silo.

Saving of labor. As compared to cutting and shocking corn in the field, the use of the silo is a distinct saving of labor. When corn is cut for the silo it is handled but once, and almost entirely by machines, and under favorable conditions.

Succulent feed. Silage feeding is the most practical means of supplying feed of a succulent character at all seasons of the year, which is a necessary part of the ration for satisfactory milk production.

Losses in the Silo. There are two kinds of losses in the silo: (1) the unavoidable loss due to fermentation of the silage material itself and (2) the avoidable, mostly losses from molding. Under proper conditions the loss in feeding value ranges from 5 to 10 per cent. The corn grain loses about 2 per cent in feeding value in the silo, which is less than for corn stored in a crib.

Losses in field curing of corn The loss in feeding value of corn shocked in the field is not great during the first four week, but before spring it becomes serious The following results were obtained by the author in a comparison of losses in the field and in the silo

	NO DAYS	PER CENT DRY MATTER LOST
In silo	82	3 05
In field	82	4 43
In field	134	43 30

Armsby and Caldwell[2] reported a loss of 21 per cent in the feeding value of corn shocked in the field Not only is the loss in dry matter much greater in the field, but a considerable portion of the fodder is not eaten on account of its unpalatability Henry reported that from 14 to 34 per cent of the fodder was wasted, and the author found from 20 to 32 per cent was refused when fed under the best of conditions to well-fed animals

Fermentations in Silage Fermentation begins in silage almost as soon as it is placed in the silo The temperature rises 8 or 10 degrees, and acid and some alcohol are formed Lactic and acetic are the chief acids which develop, the former comprising three fourths or more of the total acidity The amount of acid formed depends upon the sugar present, and the amount of sugar, in turn, depends upon the stage of maturity of the corn when it is cut As the corn matures, the sugar is converted into starch The sugar in the corn at the time of cutting is all converted into acid Where nonsaccharin crops are used, such as alfalfa and some of the grasses, some butyric acid is formed with the fermentation which may lower the palatability and add to the losses The adding of extra water has no influence upon the acidity of silage but may aid in packing Experiments show that the temperature in the mass of silage rises only 8 or 10 degrees from its temperature when put into the silo The only high temperature is found on the surface, where it may reach 130° F

The normal fermentation of silage was first attributed to bacteria Later, investigators concluded it was the result of enzymes in the live

[2] Pennsylvania Agricultural Station Annual Report p 112 (1889)

plant cells. The present view is that the fermentation is a combination of the two factors. The heat which develops on the surface and in silage thrown out of the silo but not used for some hours is mainly the result of the growth and activity of yeasts.

In many sections where corn is not used as the principal crop for silage there is an ever increasing use of forage crops and other crops for the silo. Sorghums, the legumes such as alfalfa, Sudan grass, and many other heavy-yielding and quick-growing crops make excellent silage where modern methods of preservation are used.

CONSTRUCTION OF THE SILO

Size of Silo to Build. A silo can be used to advantage where ten or more cows are to be fed. The size of the silo to use will depend upon the number of animals to be fed. A common mistake is to build a silo with too great diameter. At least two inches a day should be fed off from the entire surface to insure that the silage will not spoil. The height of the silo should be at least twice its diameter. As a rule it is not advisable to build one over fourteen to sixteen feet in diameter, since more labor is required to throw silage from one of greater diameter. If more room is needed, it is better to build additional silos. A fair allowance is from 35 to 40 pounds a day for a mature animal. Thirty-five pounds daily will require 1,050 pounds monthly, or a little over three tons to feed each animal for six months.

Table 60 gives the proper relation between the size of the herd and the capacity of the silo needed.

Essentials of Silo Construction. The essential things in silo construction are: (1) an airtight wall, smooth on the inside so that the silage can settle properly, and (2) a structure sufficiently strong to withstand the pressure of the silage and durable enough that it will not have to be replaced for some time. The material used in the construction of the silo has no influence upon the feeding value of the silage, provided it meets the requirements prescribed. The type of construction also has very little relation to the temperature of the silage or to its freezing. The silo should have a concrete floor, and no drain is necessary. A roof is desirable.

Table 60. Relation of Size of Silo to Length of Feeding Period and Size of Herd

NO. OF COWS IN HERD	FEED FOR 180 DAYS: ESTIMATED TONNAGE OF SILAGE CONSUMED	FEED FOR 180 DAYS: SIZE OF SILO Diameter	FEED FOR 180 DAYS: SIZE OF SILO Height	FEED FOR 240 DAYS: ESTIMATED TONNAGE OF SILAGE CONSUMED	FEED FOR 240 DAYS: SIZE OF SILO Diameter	FEED FOR 240 DAYS: SIZE OF SILO Height
	Tons	Feet	Feet	Tons	Feet	Feet
10	36	10	30	48	10	34
12	43	10	34	57	10	40
15	54	12	32	72	12	36
20	72	14	32	96	12	40
25	90	14	36	120	14	40
30	108	16	32	144	16	40
35	126	16	36	168*	14	34
40	144	16	40	192*	14	36
45	162*	14	36	216*	16	34
50	180*	14	38	240*	16	40

* Where this much silage is used, two silos are recommended of the sizes given

The Wooden Stave Silo. The most widely used silo has been the wooden stave. It is placed on a foundation of concrete. Little positive evidence is available as to which wood is the most suitable and durable for silo building. The following statement is supplied by the Forest Service, U.S D.A.

SPECIES	AVERAGE NUMBER OF YEARS OF LIFE UNTREATED
Cypress	14
Redwood	14
Douglas fir	10
Yellow pine	8
White pine	8

Treatment of the staves with creosote materially increases their durability. The stave silo preserves the silage as well as any type. It is easily erected and may be taken down if desired. The disadvantages are that it gives some trouble by drying out and that attention must be given to keeping the hoops at the right tension. A stave silo should be expected to last from ten to fifteen years, depend-

ing upon the kind of wood used. It is less popular today than formerly.

The Concrete Silo. The concrete silo may be built of block, staves, or with solid walls. The solid wall, or monolitic, when properly built, is very satisfactory, although the concrete stave silo, because of its cheapness and ease of erection, is replacing the other concrete types. The advantage of the concrete silo is that when once properly built it is a permanent structure, not damaged by fire. If the concrete is properly constructed so that the air is kept out, the silage will be preserved in perfect condition. In case the wall seems porous, a mixture of cement and water of the thickness of whitewash should be applied on the inside each year before filling.

The Tile Silo. This type of silo has become popular in recent years. It has the same advantages as concrete in regard to durability. It does not pit or scale as easily as the concrete silo if made of good vitreous tile. It preserves the silage equally as well as do other types. It should receive consideration by the man who desires to build a permanent structure and who is interested in style and pleasing appearance.

The Pit or Trench Silo. Pit silos are common in the Plains regions of the United States. The trench type is becoming increasingly popular in the northern parts of the Central states where freezing is a factor. The low price of construction, the ease of construction by power machinery, the use of machinery in filling and unloading, the climatic conditions, and the character of the soil in these regions are favorable. A trench silo is not suitable for a region of liberal rainfall. The soil where it is located must be firm, dry, and well drained. A curb of cement is built to extend a few inches above the ground. The walls must be absolutely perpendicular and smooth, and should be plastered with cement. With the increasing use of mechanical equipment, such as tractors, field choppers, and loaders, the trench silo is coming into much more general use. Plans for proper construction and successful use can be seemed from the College of Agriculture in most states.

Other Types of Construction. A number of other materials, used less frequently, include iron, brick, stone, and wood with a

cement lining Any of these materials may be used satisfactorily under proper conditions Thousands of temporary silos—such as the trench, bailed straw, snow fence, and many others—are now in use, and their popularity is increasing rapidly The glass-lined harvistore with mechanical unloading from the bottom is also becoming popular on the larger dairy farms

CROPS FOR THE SILO

Corn The silo has been tried as a means of preserving all the common crops grown on the farm Corn, however, is pre-eminently the crop for the silo The yield of total nutrients per acre with this crop is greater than that ordinarily secured from any other It has the further advantage of packing well and containing sufficient sugar to form the acid needed to preserve it properly In the northern states, larger yields may be obtained from some of the special silage varieties, but these produce a lower amount of grain, and it is questionable if the total nutrients obtained exceed those from varieties grown for grain

Kafir This crop stands next to corn in quality of silage It is in use successfully in those sections where small rainfall makes it a safer crop than corn The feeding value of this silage is only slightly below that of corn

Sorghum for Silage This crop stands close to corn in value for silage Almost as much feed per acre is obtained as with corn, and the quality of the silage is good Sorghum should be well matured when put into the silo As a rule, it is not ready to cut until about two weeks after the corn is cut The seed should be hard, but the stalk filled with juice If put in too early, a strongly acid silage results

Legumes for Silage Legumes, including alfalfa, clover, soybeans, and cowpeas, are best preserved in the form of hay when conditions make it possible Soybeans and cowpeas are ready to go into the silo at the same time as corn and may be mixed with corn to advantage One load of legume to three of corn makes an excellent quality of silage

Good silage may be made from the legumes, provided they do not

contain too much water If the legumes are put into the silo when they contain the full moisture of the freshly cut plant intended for hay, the resulting silage frequently will be unsatisfactory If the conditions were such that the crop could stand until in the same stage of maturity as corn at time of siloing, good silage would result Fortunately, the same results may be obtained by allowing the freshly cut material to lie in the sun for a few hours until wilted, but not

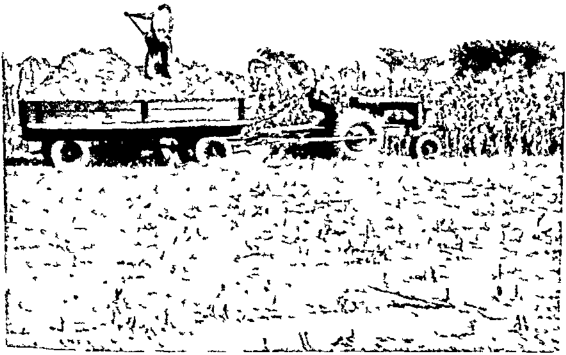


FIG 84 *Cutting ensilage direct in the field Such modern equipment is coming into general use in many sections where a large tonnage of silage is used*

dry The proper stage is about one third the way from the green material to the cured hay The chief difficulty in using these crops for silage is the cutting and handling of the heavy material without machinery adapted especially for the purpose With the advent of field choppers and other mechanized equipment, many farmers are now finding it profitable and desirable to put the first cutting of alfalfa or other hays in the silo for later summer feedings This is becoming especially popular in all sections where weather conditions make hay curing difficult

Proper Stage of Maturity for Corn It is important to fill the silo when the corn is at the proper stage of maturity Cutting too early results in too much acidity and the maximum feeding value of the corn is not realized If the corn is allowed to become overmature, a very large amount of water must be added and the quality of the silage is not the best Table 61, taken from results obtained at the *Purdue Experiment Station,*[3] shows the dry matter yield at different stages

When corn is in the milk, it contains about half the full feeding value of the mature plant The proper time to cut corn is when it shows the first sign of ripening In a year of normal rainfall, this is

Table 61 Dry Matter in Corn at Different Stages

DATE	STAGE OF GROWTH	DRY MATTER PER ACRE
		Lbs
July 24		736
August 6	Tasseling	2,248
August 28	Silks drying	4 746
September 24	Glazing	8 105
October 1	Silage stage	8 929

when the husks first begin to turn yellow at the end of the ear, while the leaves are still green The kernels should be dented and glazed

Sunflowers This crop is much used in regions where, on account of altitude or latitude, the conditions are unfavorable for corn The yield is usually equal to or greater than that obtained from corn under good conditions The sunflowers should be cut when the flowers are not more than 25 per cent in bloom

Other Crops for Silage Other crops are used in certain localities Sudan grass, grown to a considerable extent as a supplementary pasture crop, makes good silage In Oregon and Washington oats vetch and at times wheat are used with satisfactory results In the south many forage crops commonly used for pasture are also used Beet tops and the refuse material from corn and pea canneries are also preserved to advantage Rye can be preserved in the silo,

[3] Jones and Huston Bulletin 175 pp 595–630 (1914)

but the silage is unpalatable regardless of the stage at which is cut.

A.I.V. and Molasses Silage. Within the last few years, considerable research has been under way in attempts to control more completely the fermentation and losses usually occurring in the ordinary silage process. The most notable of these is a patented process of adding certain acids directly to the cut material as it is placed in the silo. This method was first developed and used in northern Europe and is commonly known in this country as the A.I.V. method. The patent claims that the process prevents the loss of carotene and certain vitamins as well as certain spoilage. Other types of chemicals such as sodium metabisulfite are also coming into common use.

Another method gaining favor rapidly in the molasses process, whereby molasses or certain types of crude sugar are added to legume crops such as alfalfa to insure the proper type of lactic fermentation. By the addition of from 60 to 100 pounds of feeding molasses per ton of alfalfa, excellent silage is assured. This method is becoming popular in alfalfa and legume-producing sections. The use of corn meal or other crushed or ground carbohydrate grains is also fairly common in many sections where such feeds are abundant and cheap.

MANAGING THE SILO

Filling the Silo. The knives on the cutter should be kept in condition so that the forage will be cut properly. Sharp knives and cutting the ensilage in very short lengths are two of the secrets of good silage. The doors of the silo should receive attention in order that the air may be properly excluded. A covering of tarred paper is generally advisable. When the filling is completed, the top should be leveled off and tramped down as thoroughly as possible. The surface should be wet thoroughly by running in considerable water with the last few tons or by putting it on the silage after the filling is complete. Using greener material for the last few loads is advocated. The silage should be tramped firmly against the wall daily for several days. Some persons follow the practice of cutting two or three loads of green grass or weeds after the corn is in. The heavy material

helps to form a seal. The surface may also be covered with building paper and weighted down. If carefully done, practically no spoiling on the surface will be found.

A distributor saves much labor and results in a better distribution of the grain with the forage. The cut material should be wet to the touch. If the corn was at the proper stage of maturity, no water

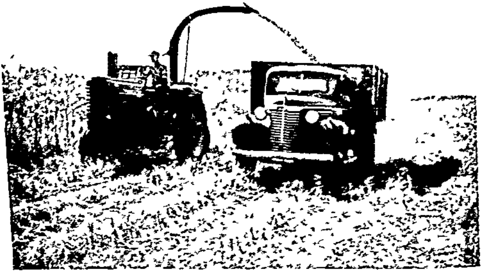


FIG. 85. The modern field chopper reduces heavy labor and is returning the silo and the use of ensilage to its proper place in dairy-cattle feeding

will be needed If past the proper stage, or if the corn becomes dry in the field after cutting, water should be added. If the corn has reached the stage where the leaves are dry, a large amount of water will be necessary

Spoiling of Silage. Two types of spoiling are found in silage. *The most common is molding The other is rotting.* Both forms of spoiling require the presence of air before they can develop. The main factor, therefore, in preserving silage is a complete exclusion of air. Air cannot be excluded unless the silage is wet and well packed.

Moldy silage, unless around the wall or doors, nearly always indicates lack of sufficient moisture at time of filling. It may also be found near the wall and doors because the walls were not tight and thus air was allowed to enter through cracks or around the doors. A lack of sufficient tramping next to the wall during filling may also be the cause of the trouble. The rotting of silage appears when air gains access to silage having plenty of moisture. It usually is found near the doors and may be accompanied by the development of considerable heat.

Sealing the Silo. *Much more attention should be given to sealing the filled silo properly than is commonly done.* A good seal can be secured by first well tramping and packing the top layer of silage. A top layer of old chopped hay or straw can then be applied. Often planting a heavy seeding of oats or rye is also very effective. There are now on the market plastic silo caps or sealers that are very effective and can be reused each year. Common two-ply roofing, if well laid, makes an effective seal. Any method that completely excludes *air makes an effective seal and saves silage* from top layer spoilage.

Capacity of Silos. The weight of corn silage is subject to considerable variation, caused especially by the wide differences in water content and, to some extent, to the amount of grain contained in it. King[4] in 1893 published a table giving the estimated weight of silage for silos of different sizes. His figures give results somewhat too high for present use on account of the practice in recent years of allowing the corn to reach a more mature stage before putting it in the silo. The original author and his associates published a new table for this purpose based upon results from thirty-three silos. This table is found in the Appendix.

Mechanical Unloaders. Within the last few years a number of different mechanical units have been developed which automatically unload the amount of silage needed at each feeding. Where electricity is available these take a lot of hard work out of the daily handling of silage and are *gaining much popularity.*

[4] *Wisconsin Agricultural Experiment Station, 10th Annual Report, pp* 201–227 (1905).

CHAPTER XXXI

Pastures and Soiling Crops

PASTURE

Importance of Pasture Pastures of one kind or another furnish a large portion of the nutrition of the livestock of the United States Improved or tame pastures in 1945 amounted to more than 175 million acres Of this vast acreage some 48 million acres were of the cultivated type and were a part of the regular rotated-crop system of the farms, yet are the most poorly managed of all American farm crops It is on these heavier, more productive pastures that most of the dairy cows of the United States are pastured during the pasture season Pastures can be the cheapest and most efficient means of feed production for dairy cattle With the nationwide program of land conservation and the recognized place of grass as a cover crop for land conservation, pastures are due to have increased use and importance

Wide Variation in Pastures Pastures vary greatly in their ability to produce feed Some pastures under the best grassland management of intensive fertilization, proper seeding, and rotational grazing will furnish the daily roughage requirements of a dairy cow for the season from as little as one acre Other pastures are so poor and limited in their producing capacity that ten or more acres are required Lands in the United States giving the greatest amount of satisfactory grazing per acre are not the ones most pastured Such lands are more often used for cultivated cash crops, and pasture is more often confined to the poorer, less fertile part of the farm This is

quite the reverse of the high regard for pastures and the use of land for pastures in England and Europe, where the best fields of the farm are those used for pastures. There also, pasture lands receive the same attention of fertilizing, seedling, and management as the rest of the farm.

Permanent Pastures. Permanent pastures are usually designated as those pasture areas that are covered with perennial or self-seeding plants and are not planned as a part of the crop rotation but are grazed year after year. Because they are not a part of the regular cropping system they are most often neglected, never manured or fertilized, and are most often overgrazed, especially in dry seasons.

Much of the covering turf becomes thin, weedy, and made up of nonnutritious types of plants and grasses which produce little of the nutrients needed for satisfactory milk production.

Improvement of Pastures. Because of increasingly widespread recognition of poor pastures and the low returns secured from them, much research in recent years has been directed to pasture improvement. Such research shows the possibilities of great improvement even on the poorest pasture lands. Research in pasture improvement in Michigan and other dairy states has shown that the permanent common bluegrass pastures can be greatly improved in productivity during the early pasture months of May and June and the fall season of September and October by regular applications of a complete fertilizer up to 500 pounds per acre. The use of barnyard manure should be much more widely practiced. Renovation by disking, liming, reseeding, and fertilizing is becoming recognized as necessary and profitable in handling badly run-down permanent pastures and returning them to profitable use. The addition of quickly responding nitrogen fertilizers during the growing and grazing season stimulates new growth and is now being much used in good pasture management.

Rotation on Cultivated Pastures. Rotation pastures are best suited to dairy cattle. Dairy cows must secure their feed in a short time and without too much walking or exertion in grazing. A dairy cow producing 35 pounds of milk per day will require more than 125 pounds of pasture grass to maintain this production. Therefore, pas-

tures for heavy-milking cows must be of heavy growth of nutritious, appetizing grass It must be abundant and in constant supply, and only productive, well managed pasture fields will supply this need Frequent rotation at short intervals of all cows will keep them on pastures that are most abundant and in the highest state of dry matter content and nutrition Rotation pastures are usually planned as a part of a short farm rotation of cultivated fields in which pastures of only one or two years, together with hay and corn for silage make up the rotation

Grass mixtures suitable for such cultivated pastures in most dairy sections usually contain some such legume as alfalfa, clover, or lespedeza in combination with the grasses best suited to the locality Alfalfa brome grass is becoming widespread in its use, especially in the North Central dairy sections Orchard grass and Ladino clover are becoming widely used as well as many other special mixtures suited to special conditions Such pasture mixtures not only furnish much more feed per acre for a longer pasture season, but the type of feed has much higher milk producing qualities than the usual native or permanent pasture grasses Such well planned, cultivated pastures go a long way in producing cheap milk and in solving the midsummer feed shortage so common on dairy farms

Economy of Good Pastures In recent years, with the higher costs of grains and concentrates for dairy feed, much research has been done in the leading dairy states on the economy of good pastures in lowering the cost of milk production In Michigan alfalfa alone or alfalfa brome grass for pasture proved twice as productive in dairy and livestock returns as did the best Kentucky bluegrass under the same conditions of weather and soils In a three year trial at its W K Kellogg Sub-Station the Michigan State College secured the grazing returns per acre for alfalfa brome and alfalfa alone for dairy cows[1] This is summarized in the table on page 525

Figures released by the U S Department of Agriculture[2] covering the cost of 100 pounds of digestible nutrients from various crops

[1] Rather Harrison Brown, and Horwood Michigan Agricultural Experiment Station Bulletin 159 (1939)

[2] Woodward Shepard U S D A Clip Sheet 949 (1936)

own for feed production in some sixteen states show the economy asture.

n Kansas 100 pounds of digestible nutrients were produced from ture at a cost of 10 cents, from corn at a cost of 64 cents, and

le 62. Feed Returns and Milk Yield from Alfalfa Pastures

ITEMS	ALFALFA-BROME PER ACRE				ALFALFA PER ACRE			
	1936	1937	1938	Average	1936	1937	1938	Average
lk production (lb.)	3,304	4,346	4,113	3,933	3,090	4,664	3,065	3,606
tterfat produc- ion (lb.)	148	202	186	179	140	219	136	165
ncentrates fed (lb.)	828	522	1,185	845	892	810	763	822
rn silage fed (lb.)	570	—	—	—	570	—	—	—
falfa silage fed (lb.)	—	1,860	863	—	—	1,700	—	—
sture days	99	175	160	145	99	168	106	124
et T.D.N. from pasture	1,144	2,008	1,487	1,549	1,002	1,865	1,227	1,371

able 63. Cost of Producing 100 Pounds of Digestible Nutrients

CROP	TOTAL DIGESTIBLE NUTRIENTS PER ACRE	COST OF PRODUCING 100 LBS OF TOTAL DIGESTIBLE NUTRIENTS
Oats	932	$2 02
Barley	1,217	1 70
Corn silage	2,320	1 64
Corn grain	1,778	1 38
Alfalfa hay	2,522	83
Pasture	—	64

from alfalfa hay at a cost of 26 cents. At the Ohio Station 100 pounds of digestible nutrients were produced from improved pastures at a cost of 26 cents, from alfalfa hay for 50 cents, and from corn at $1.00. The Louisiana Station reports feed from pastures worth from $40 to $50 per acre.

A good pasture under proper management should produce from

1,500 to 2,000 pounds of digestible nutrients per acre per season The value of such production can be easily determined by computing the value of the digestible nutrients in the concentrates saved by its use

Supplementary Pastures Where pasture is relied upon to furnish most of the nutrients for milk production during the summer season, it is often necessary to plan for some supplementary crops as a safeguard against hot dry periods or shortage of production of regular pastures

The most satisfactory crops to supplement regular pastures are alfalfa, sweet clover, rye, and Sudan grass

Rye is one of the hardiest of all grains and grows late in the fall and early in the spring It provides heavy early pasture and can be provided to allow regular pastures to get a start in the spring and to recuperate late in the fall Some of the new varities of rye, such as the Balbo, are especially suited for pasture use

Sudan is a quick-growing drought-resistant grass It is especially a warm weather crop and best suited to use in the hot, dry, midsummer season when other pastures are inadequate or dormant It is a fast-growing crop and provides an abundance of succulent, nutritious material It is slow to start, requires a good seed bed, and should not be used until well developed It is best used by dividing into small plots for quick grazing If when it has been grazed off it is allowed to rest, quick new growth takes place, making good late pasture In the south where dairying is advancing rapidly much attention is being given to suitable pasture mixtures Dallis grass and White Dutch Clover are being used to extend the grazing season Bermuda grasses and other grasses adapted to the particular section are being used with various legumes Winter barley, oats, rye, and winter wheat furnish good winter grazing in many southern sections and still yield a satisfactory grain crop after dairy cattle have been put on regular spring pasture

Having a reserve field of alfalfa or some other suitable legume crop always available makes one of the most satisfactory supplementary pastures If not needed, it can always be used for hay and it fits well into the regular cropping program

SOILING

Soiling means growing green forage, cutting and bringing it to the stock, in place of allowing cattle to eat the green feed where it grows. This system is one that, as a rule, goes with intensive farming and high-priced lands. It is also practiced in some other regions because the conditions there are such that good pasture cannot be had. In many parts of the world—for example, the greater part of Germany—cattle are never grazed. The system is also followed to some extent in the eastern states and in Central West in dry seasons or during certain months when pastures are short and need supplementing. The proper use of silage in the summer can serve the same need.

General Advantages of Soiling. When green feeds are used only to supplement pastures for part of the season, the practice is spoken of as partial soiling. When the animals are sustained entirely on green feed, cut and hauled to them, the plan is called "complete soiling." It is not implied in either case that the animals do not receive any feed, such as grain, other than the green feed given, but that green feed constitutes the main part of the ration. On account of the comparative cheapness of land over the greater part of the United States and also the widespread use of the silo for summer and supplementary feeding, the system is not widely practiced except in isolated localities. Its advantages are:

1. Saving of land.
2. Saving of fencing.
3. Saving of the manure.
4. Animals kept in better condition.

Saving of land. The greatest advantage that can be urged for soiling is the much greater return in feed that it is possible to secure from a given area. This saving of land comes about in three particular ways. The most important is that the crops are allowed to become more mature before being used. When pasture grass is eaten in an immature form, it is not given opportunity to utilize its leaves and roots to the best advantage to build up the plant. It is a demonstrated fact, for example, that the corn plant gathers the

greatest part of its nutrients after the plant is fully grown If the growth should be cut off as soon as it reaches the height of a few inches the yield of feed per acre will be very small The same is true—to a lesser degree, however—for grasses Forage crops used for soiling are cut when nearly mature, but before they have become woody and unpalatable

The second reason why pasturing does not yield as much feed as soiling crops is that in the former the plants are injured by the treading of the feet and the soiling of the grass with manure

A third reason to be taken into account is the injury done to the land by the trampling of the stock, especially during wet weather

By following the soiling system Detrick,[3] who was one of the early advocates of soiling and whose remarkable results have been widely quoted, was able to raise all the roughage needed for thirty head of stock, of which seventeen were cows in milk, on seventeen acres The land on which these results were obtained was, in the beginning, so run down that it would hardly support three animals The fertility was built up by barnyard manure until two crops per year, together equal to about 6 7 tons of hay per acre, were produced

At the Wisconsin Experiment Station three cows were maintained on 1 5 acres of soiling crops Three other cows on pasture required 3 7 acres The conclusion was drawn from this work that one acre of soiling crops equals 2 5 acres of pasture

The Connecticut Experiment Station maintained four cows from June 1 to November 1 on 2 5 acres of soiling crops The Kansas Experiment Station[4] reported the following results in a year of more than average good pastures Ten cows were used

CROP	DAYS FED	YIELD PER ACRE LBS
Alfalfa	14	77 145
Oats	9	12,325
Corn	31	38 695
Sorghum	15	22 3 0
Kafir	14	17 550

[3] U.S Department of Agriculture Farmers Bulletin No 242 (1905)
[4] Kansas Agricultural Experiment Station Bulletin No 119 (1903)

The average consumption was 116 pounds per head daily, and .71 acre fed one cow for 144 days.

Taking into account all the data reported, it seems conservative to say that when following the soiling system one acre will produce at least twice as much, and often three times as much food as an acre harvested as pasture.

Saving of fencing. The second advantage of the soiling system is the saving of fencing Fences are an item of large expense on any stock farm, especially when it is necessary to divide the land into small areas in order to utilize it to the best advantage. The initial cost of fences is considerable, and in addition they require almost continual repairs. This expense for fences is largely eliminated by the soiling system. The present rapidly spreading use of the one-wire electric fence makes this item of less importance than formerly. In Germany, where the soiling system is almost universal, no fences at all are in use. Practically no fences are used in Denmark, where the cows are not turned loose on pasture, but are tethered out constantly.

Saving of manure. The third advantage of the soiling system is the better saving of the manure. The actual value of the excreta passed by a cow in a year for fertilizing purposes is about $30, if all is preserved. If the animals are on pasture, nearly half of this will be dropped in the pasture, where much of its value may be lost. In most cases a much greater value would be realized from applying this fertilizer to other parts of the farm. When the cattle are kept housed, as they usually are when soiling is practiced, the manure may be preserved and applied where most needed. On some farms this is a point of great importance.

Animals Kept in Better Condition. As a rule cows keep in better condition where a soiling system is followed than under average pasture handling. This is due largely to a more adequate and regular feed supply than under pasture and also helps to reduce the ordinary summer decline in milk production.

Objections to the Soiling System. There are two objections to the soiling system which prevent its wider adoption: (1) mainly the labor problem, and (2) difficulty, because of weather variations, of

providing a suitable series of crops and adjusting the amounts of each

The soiling system involves a much greater expense for labor than when the pasturing system is used The green feed must be cut each day, or at the outside, every second day. The common practice is to cut it daily, except Sunday, when the animals are fed from a larger amount prepared the previous day Since the amount required

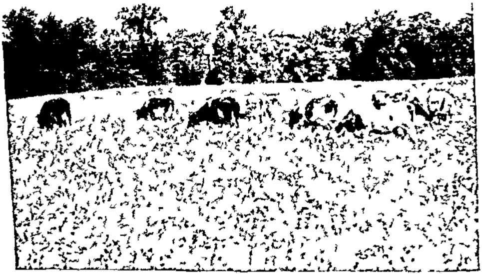


FIG 86 Soiling crops are being replaced by cultivated and rotated pastures, such as Sudan grass and other heavy producing pasture crops

per day is approximately 100 pounds per cow, the weight to be handled is considerable, making the labor heavy, yet is not enough to justify labor-saving mechanical equipment except with the larger herds This is especially objectionable during rainy weather.

A further difficulty about the labor feature is the regularity required of attendants, which is difficult to secure in these days of shorter working hours In addition to the labor of preparing the green food the labor of handling the manure and caring for the

animals from day to day is much more than for pasture handling. Furthermore, the difficulty of securing a suitable succession of crops in about the right quantity requires careful planning when complete soiling is practiced. There must be a succession ready to use all the time, and in about the proper quantities. Because of the great variability in weather this is especially difficult in most sections of the United States. Too often a feast or a famine is the common experience.

Crops for Soiling. The crops to be grown for soiling purposes depend naturally upon the local conditions, and no general statement can be made to cover all conditions. Information regarding the best crops for the purpose can be had from the nearest experiment station. Shaw[5] gives the following list of suitable crops:

> For Canada and the Eastern States north of the Ohio River: winter rye, alfalfa, medium clover, mammoth clover, peas and oats, corn, sorghum, millet, and field roots.
>
> For the northern part of the Mississippi valley: the same, except for alfalfa which is omitted.
>
> For the Southern States: winter rye, winter oats, crimson clover, corn, sorghum, cowpeas, and rape are suggested. In sections where alfalfa can be grown, it should be included by all means. In the southwestern part of the United States more attention should be given to alfalfa, soybeans, and millets.

The recommendation of the Pennsylvania Experiment Station[6] regarding succession of crops and acreage for ten cows is given in Table 64.

Table 64. Soiling System Suggested by Pennsylvania Experiment Station

CROP	AREA	WHEN TO BE FED
Rye	½ acre	May 15–June 12
Alfalfa	2 acres	June 1–June 12
Clover and timothy	¾ acre	June 12–June 24
Peas and oats	1 acre	June 24–July 15
Alfalfa (2d crop)	2 acres	July 15–Aug 1
Sorghum and cowpeas (after rye)	½ acre	Aug. 11–Aug. 28
Cowpeas (after peas and oats)	1 acre	Aug. 28–Sept. 30

[5] *Soiling Crops and the Silo.* Orange Judd Company, New York (1900).
[6] Mairs, Bulletin No 75 (1905).

Suggestions by *Gillette, McCandlish, and Kildee*[7] based upon work at the Iowa Experiment Station for a soiling system using alfalfa are given in Table 65

Table 65. A Soiling System with Alfalfa

CROP	AREA ACRES	APPROXIMATE DATE OF SOWING	APPROXIMATE DATE OF HARVESTING	APPROXIMATE YIELD PER ACRE TONS
Alfalfa first cutting	½	Previous year	June 10–20	8
Oats and Canadian field peas	1	April 5	June 15–July 5	6
Oats and Canadian field peas	½	April 20	June 30–July 30	5
Alfalfa, second cutting	½	Previous year	July 5–15	4
Oats and Canadian field peas	½	May 5	July 10–25	5
Amber cane	1	May 20	July 20–Aug 20	12
Amber cane	1	June 20	Aug 15–Sept 20	12
Amber cane	1	July 5	Sept 10–Oct 15	12

[7] Iowa Agricultural Experiment Station Bulletin 187, p 51 (1919)

CHAPTER XXXII

Barns for Cows

The dairy cow, unlike the fattening steer that is protected by layers of fat, needs to be comfortably housed if she is to do good work. Exposure to cold—and especially to cold winds and rains—results in much larger losses than the actual amount of feed required to maintain the animal heat under unfavorable conditions. Forbes found that, for each one degree Fahrenheit below the temperature at which a cow begins to feel cold at rest, indicated by shivering, the amount of feed "burned" in order to keep warm was increased by 1.4 per cent of the normal maintenance requirement. The importance of housing is generally understood and practiced in the colder climates. As a rule, more losses from exposure occur in those regions where, because of the usual mildness of the climate, sufficient provision is not made for occasional severe weather.

Barn a Human Food Factory. It must be recognized that the barn is a place in which human food is produced, and, further, that the health and even the lives of the children of the country depend to a large extent upon the conditions existing in the barns where the milk, which serves as their main food, is produced. There is a strong and growing demand on the part of milk consumers and officials who have to do with the health conditions of the cities for better sanitation in the barns and dairies. Laws and regulations regarding this matter are becoming more stringent, and an immense improvement has been brought about within the past few years, but there is still a great deal to be accomplished along the line of more sanitary and comfortable housing of dairy cattle.

Better Barns Mean Cheaper Production There is another phase of the subject that must be emphasized as well There is no doubt that it pays as a financial proposition to have well-arranged, sanitary barns which make the cow more productive by making her more comfortable, which make labor more efficient on account of being better satisfied, and which lessen the expense of labor by their convenience in arrangement A sanitary barn is not necessarily an expensive one Many an inexpensive structure is or may be more sanitary than some ill-arranged, badly kept but expensive barn

The dairy cow does her best in the early part of the summer when on a good pasture The maximum production reached at this season is possibly due largely to the excellence of the food, but at the same time the animal enjoys a moderate temperature and clean, comfortable surroundings There is an abundance of fresh air and sunlight, and the cow has perfect freedom of movement Every effort should be made to duplicate these conditions as far as possible in the dairy barn A cow housed in a dark basement barn, surrounded by foul air, with her head fast in a rigid stanchion and her body more or less filthy is as far from summer conditions as her milk production is below that of early summer

Types of Barns There are various styles of barns, but they may be divided into a few rather distinct types, which are as follows

1 The basement barn
2 The two story or loft barn
3 The one story or shed barn
4 The round barn
5 The pen type barn

The basement barn The basement barn is a favorite type in the northern part of the United States, especially in the eastern states Most of the older barns are of this type It cannot, by any means, be recommended as an ideal dairy barn It is built by excavating into the side of a hill sufficiently to bring the top of the first story on one side, and usually on two sides, at the level of the ground outside, the south and east sides commonly being full height above ground This type of barn is warm, but usually very unsanitary, on account

of having practically no light and no ventilation. It can be ventilated, but rarely is this done. Space for storage is usually provided above the animals, with a driveway running directly into the loft. Many of these older basement barns are now being remodeled into the pen type barn described later.

The two-story or loft barn. This style of barn allows for the stabling of the stock on the first floor, with a second story for storage

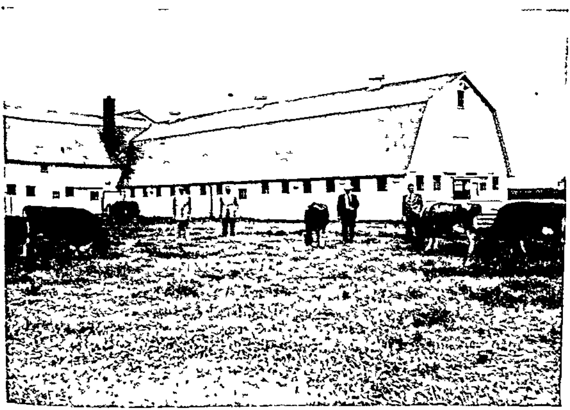


FIG. 87. A modern two story dairy barn The stable for cows is on the ground floor, and the loft is for hay storage and bedding Note the numerous windows and ventilators

above. The walls of the first story may be of stone or wood, but are all above ground. This style is well adapted to the general farm where considerable room is required to store the loose hay and other feeds grown on the farm for winter use. Storage room is secured more cheaply in this manner than by building a one-story cow barn and a separate storage barn. This style may be entirely sanitary in its construction, if properly arranged. It should have plenty of light and a good ventilating system. The ceiling above the cows should be tight

to prevent dust from falling and so contaminating the milk, and to avoid the odor from the stable and the breath of the animals from injuring the palatability of the feed above

The one-story or shed barn This is one of the best types of barn from the standpoint of sanitation and convenience It usually is built wide enough for two rows of cows This plan is especially adapted for use where it is not necessary to have any large amount of storage

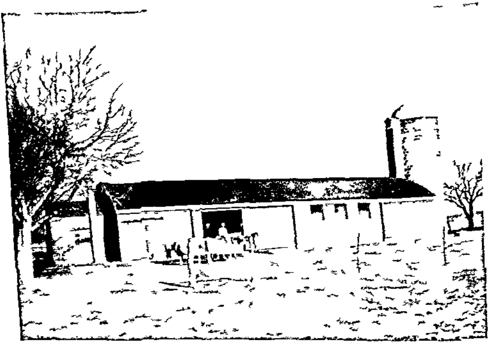


FIG. 88 A one story dairy barn with silo attached

room for unbaled hay or bedding It is often used, however, where ample storage room must be provided, and in such cases a portion of the barn is usually built two stories high, and serves for storage and general purposes while one or more single-storied wings are provided to house the cattle The single-storied barn usually has a tight ceiling, although in the south and warmer climates some are open to the roof and have a monitor top to admit light from above The objection to having the space open to the roof is that in cold climates this space is so great that the barn is too cold in winter

The advantages of the one-story barn are that it may be well lighted and ventilated and its construction made sanitary in every way.

The round barn. The economy of construction in the round barn was first called to attention by King. According to this author, a round barn requires 25 per cent less wall to enclose it than does an ordinary rectangular type.

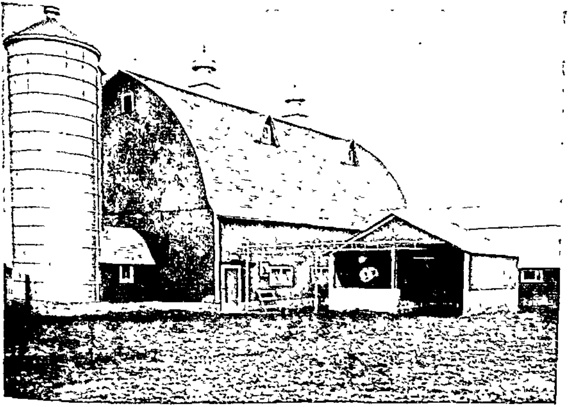


FIG. 89. A modern dairy barn found on thousands of average American dairy farms.

A round barn with room for forty cows requires 22 per cent less walls and from 34 to 58 per cent less material than a rectangular building with accommodations for the same number of animals. The silo is built in the center, and the cows are usually arranged in a single row around the barn, headed toward the center, except where the barn is too large, when a double row is used. The round barn has not won its way into popular favor. Its disadvantages are difficulty in filling the silo, the impracticability of increasing its size by build-

ing additions, and the use of mechanical equipment It is seldom built today

The pen type barn This plan was first called to the attention of the public by Roberts and Wing of Cornell University, who used it for many years with the station herd of dairy cows The plan consists in having a large shed or covered yard, into which the cattle are turned loose except at milking time The roughage is usually fed in racks to be consumed at will These racks are arranged so they may be moved against the roughage supply and may then be self feeding The grain is fed when the cows are taken to the milking parlor at milking time The milking parlor need not be elaborate, but it must be sanitary The cows are stanchioned while they eat their grain and are milked Pen type barns require much less labor in caring for cows and make mechanical devices for handling feed and bedding much more easy to use This system gives the cows a maximum amount of freedom but requires an abundance of straw for bedding A great advantage of pen type barns is to be found in remodeling old barns They generally are of undesirable size or dimensions for standard barn equipment but may be gutted to form the open-shed part, and by the addition of a simple milking quarter, a modern and economical barn may be secured at low cost In recent years much development has taken place in labor-saving design and convenience in pen type barns and efficient milking parlors This type of barn is becoming increasingly popular in all dairy sections

Location of the Barn The barn should be located where there is good drainage making it possible to keep the yards in good condition Convenience in location as well as in plan should receive careful consideration, since the expense for labor depends to no small degree upon proper location and internal arrangements of the barn

A rectangular barn should stand preferably north and south, or with long axis northwest and southeast, making it possible to get sunlight on both sides at some time during the day

Lighting One of the most serious defects in most barns, particularly the older ones, is lack of sufficient light Windows cost little if any more than other wall materials and cannot be objected to on this account Plenty of light is one of the most essential things about

a good barn. It is necessary to keep the animals in a healthful condition, and is of the greatest importance in a sanitary way. Not only does sunlight destroy germs, but where there is plenty of light, unclean conditions are easily seen and corrected. A dark barn is almost always a dirty barn. There should be at least 4 square feet of glass to each animal. The bottom of the windows should be 4 or 4½ feet from the floor; if lower, the animals are likely to break the glass.

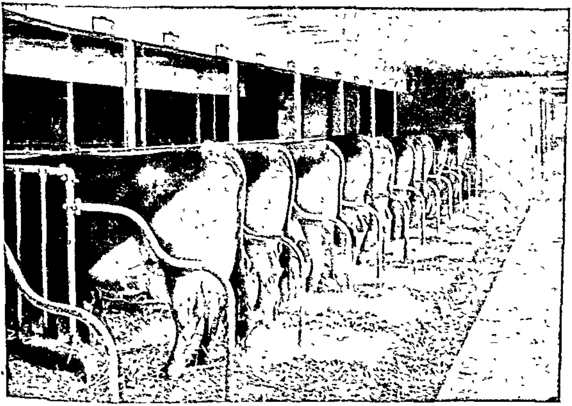


FIG. 90. A well lighted barn. An abundance of light is the first requirement for a sanitary barn. A light barn is usually clean, a dark barn seldom.

The windows should extend nearly to the ceiling in order to allow the sunlight to reach as much of the floor as possible, and should set flush with the inside wall to avoid making a ledge for the accumulation of dust. In a one-story barn the windows should be hinged at the bottom. In a two-story barn, which gives ample room above, the sash had better slide upward. This arrangement is much more convenient than having one sash slide past the other in the ordinary manner. In sections where the winters are severe, the barn may be made more comfortable by the use of storm windows and double doors.

Floor Construction One of the most important points to be considered in planning a barn is the material to be used for floors Material for a floor should have the following characteristics

1 Impervious to moisture
2 Sanitary and easily cleaned
3 Comfortable for the cows not slippery
4 First cost not too great
5 Durable

The floors in common use are as follows

1 Dirt with wood or cement gutters.
2 Wood.
3 Brick.
4 Cork brick.
5 Concrete

Dirt floors A floor of dirt in a dairy barn is excusable only under primitive conditions This material provides comfort for the animal and is cheap in construction The objections are, of course, that it cannot be kept clean and that it cannot be disinfected after an outbreak of disease The most objectionable condition is having the cows stand on a level dirt floor without any gutter A fairly good floor for ordinary purposes may be made by building a gutter of cement or wood, and extending this forward far enough to catch the urine The space under the cows is then filled with clay packed solidly When sufficient bedding is used, such a floor will answer in a cheap barn but under no circumstances could such a barn be called sanitary or modern

Wood for floors A tight, wooden floor is comfortable for the animals and may be kept in good condition regarding cleanliness, although it can hardly be considered first-class from a sanitary stand point. The first cost is also excessive, considered from the standpoint of the time it remains in service Under the most favorable conditions, a wooden floor may last six to ten years The most rapid decay occurs when the floor is laid far enough above the soil that only a small amount of moisture is present and when there is no circulation of air underneath Under such conditions the floor may not last longer than three to five years

Wooden floors are made watertight by using coal tar between the planks. The most serious objection to the wooden floor is its short period of service. When moist, a wood floor is slippery and cows are liable to severe falls while they are moving about. Another objection of considerable weight in many cases is the sanitary question. On account of the difficulty of cleaning, a wooden floor is not used where the greatest attention is paid to sanitation. Creosoted wood blocks may be used to advantage.

Brick for floors. If good vitrified brick can be bought cheaper than cement, this material may be used with advantage. A brick floor has the same advantages and objections as those discussed in connection with cement. The bricks must be put on a good foundation and set in cement, which adds to the cost.

Cork bricks. For stall floors, cork brick is fairly popular. While the initial cost is rather high, it makes a floor which is comfortable, sanitary, easily cleaned, and fairly durable.

Cement floors. Cement or concrete has more of the requirements for a good floor than any other material in general use. This material is impervious to moisture, very durable, and the most sanitary and easily cleaned of all. The first cost is no more than wood in most localities, and its lasting properties make it much cheaper, considering a term of years. The one serious objection to cement is in regard to the comfort of the animal. A cement floor is cold, that is to say, it is a good conductor of heat, and for this reason seems cold. It is believed by many of the most experienced dairymen that udder troubles are brought on from cows lying on cement floors. This difficulty may be lessened by having the floor from 6 to 9 inches higher than the surface of the ground on the outside to prevent water from flowing under the cement. The floor should be thoroughly insulated with a layer of cinders 6 to 9 inches deep under the cement. Such arrangement, together with a liberal use of bedding, will remove most of the danger from the coldness of the cement.

Another serious objection to cement is the slipping of the animals as they come through the passageways. A cement floor should never be trowled to a smooth finish, but left with the surface rough, as finished with a board. Some concrete floors are built with coarse

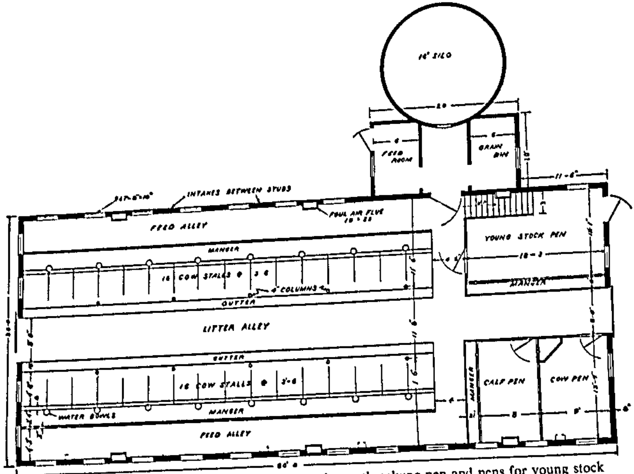
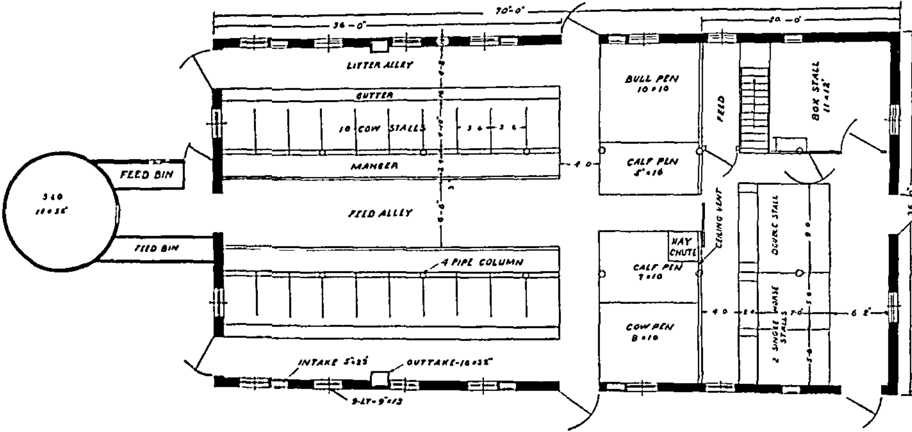


FIG. 91. Floor plan to house 32 milk cows together with calving pen and pens for young stock



FLOOR PLAN

FIG. 92. Typical floor plan of a general barn in common use.

emery or carborundum aggregate in the surface layer or grout These are then wood floated for a rough finish Such a surface is not slippery and reduces accidents of both cows and workmen In some barns sand or raw crushed limestone is sprinkled on the floor daily to prevent the animals slipping Another trouble that often occurs is injury to the knees of the cows As the animals reach into the manger for food, the forefeet slip and the cows drop on their knees, which results after a time in enlarged joints This trouble is in a large measure avoided by making a depression of an inch where the forefeet stand

Another good plan is to construct the entire floor of the barn—including the stalls, passageways, and mangers—of cement, then to cover the platform where the cows stand, as suggested, with cork brick on a cement foundation Creosoted wood blocks also make a satisfactory stall floor when carefully laid on a good foundation and the joints flushed with cement wash Several new mastic materials are now being used in dairy barn floor construction They offer many possibilities

Wall Construction. Wood, concrete, tile, masonry, or brick may all be used in the construction of barn walls, and the cost will ordinarily be the determining factor The inside of the walls should be smooth in order to be easily kept clean A well-painted, tight, wooden wall is as easy to keep clean as one of concrete The matter of warmth enters into the selection of material for the walls, and the walls should be insulated to prevent condensation of moisture in the form of frost during cold weather A wall made of lumber with tar paper underneath and an air space between the outer and inner surfaces proves fairly warm. Hollow tile with its dead air space makes an excellent barn wall Concrete is extensively used, but when built up solid it is cold and the moisture in the air of the barn condenses on the surface of the concrete, sometimes forming a very thick coating of frost This may be remedied to a large extent by a double wall with an air space between, but this entails additional cost of construction In localities where winters are mild, concrete is unquestionably the best material for at least the lower section of the barn walls, because of its durability and the ease with which it can be kept clean

Arrangement of Cattle in Barn. The best and most commonly used plan is to stand the cattle in a double row, thus making it possible to light the entire stable readily, to feed, and to remove the manure conveniently. There is much discussion as to the comparative advantages of placing the cows with their heads together or with heads outward. There are some advantages in favor of each. When facing the center, both rows may be fed by making one trip down the passageway with the feed truck, distributing the feed on both sides. The removal of the manure is most convenient when the animals are headed out, since by driving through with the manure spreader and loading directly from the trenches, considerable labor is saved, or if a track carrier is used, it may be loaded readily from both gutters. The cows present a better appearance to visitors when headed out; the walls of the barn do not become splashed with manure, and there is some advantage in regard to ventilation, since the fresh air usually enters along the outside wall. Facing inward brings the milker nearer to the light and enables him to see if the udder is clean. However, the opposite arrangement is more convenient when milking machines are used. The greatest difficulty that is usually experienced in heading the animals outward is the construction of the barn without the use of center posts that obstruct the passageway behind the animals. When the cows are headed toward the center, the posts for support are made part of the stanchion manger supports, and are not in the way. However, with more expense it is possible to support the longer span required with trusses when the cows are headed outward. Figs. 93 and 94 show cross sections of barns conveniently arranged. The width of the barn is 36 feet. The walls should have cement plaster 3 feet high made with a rounded corner to prevent accumulation of dirt. The passageways should be of ample width to facilitate feeding and cleaning.

Gutters. The gutter is highly important in connection with keeping the cow clean. It should be of ample depth, as otherwise cows are apt to stand with the hind feet in the gutter. The depth should not be less than 8 inches, while 10 or 12 inches is better. The proper width is not less than 16 inches. The danger from deep gutters is that the cows will slip and injure themselves. This may be largely eliminated

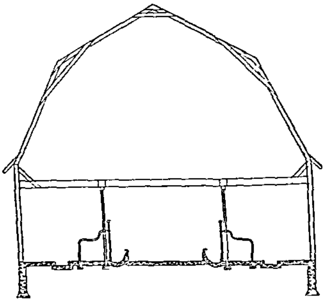


FIG 93 A cross section of a two-story barn The cows are facing the center in this diagram but can be reversed The modern loft barn is braced without heavy timbers, resulting in a saving of timbers as compared with the older style and in a much more convenient mow in which to store hay

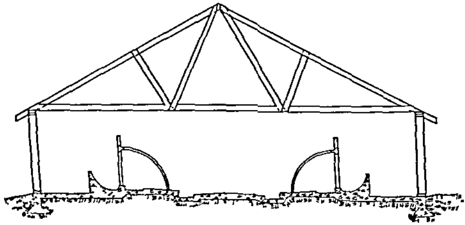


FIG. 94 A cross section of a one story cow barn In this diagram the cows are faced outward They may be faced toward the center if preferred This type of barn is suitable where storage for hay is not needed

by lowering the passageway behind, making this side of the gutter only 6 inches deep.

Mechanical gutter cleaners. Recently several different types of mechanical gutter cleaners have been on the market. Where electricity is available and the barn of modern type, they are very satisfactory and save much labor and time in caring for cattle.

Mangers. There are numerous types of mangers. From a sanitary standpoint, cement is the best material for construction. All corners should be rounded to facilitate cleaning. The most common

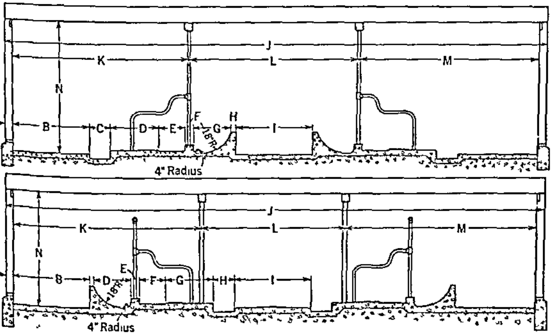


FIG. 95. Cross sections of a barn showing cows facing in and out. Preference is largely a matter of personal opinion.

type is the continuous manger, which is built in the form of a long trough before the cows. Some objections are raised to this construction, on account of the chance it affords one cow to rob another of her feed. In case of contagious diseases like tuberculosis, there is also much more danger of communication from one animal to another in such a manger. Partitions of sheet iron are sometimes used. The special advantage of the continuous manger is the ease of cleaning by sweeping out refuse feed. Fig. 95 shows a cross section of a barn from the middle of the feedway to the outer wall, giving the proper

dimensions The width of the manger should be not less than 2 feet, and preferably it should be 2 feet 6 inches The bottom of the manger should be 1 or 2 inches higher than the platform where the cows stand The outer wall of the feed manger should extend inward at the bottom or floor level This facilitates feeding, cleaning the mangers, or working around the head of the cows

The curb next to the platform on which the cows stand should be 6 or 8 inches above the level of the bottom of the manger

Platform The comfort of the cows and success in keeping them clean depend largely upon the construction of the platform It is highly important that it be of proper length and of suitable material

The construction to be recommended most highly is of cement or, better still, concrete overlaid with creosoted wood blocks or some of the newer mastic preparations A cement platform should have a depression 1 inch deep and 14 inches wide next to the tie The surface of this depression should be slightly fluted The object in this is to prevent the cows from slipping and falling on their knees when reaching for feed It also allows the cow to stand on the level, since the platform slopes one inch from the rear of this depression to the front edge of the gutter Success in keeping the cow clean depends largely upon having a platform of proper length The length to be used varies from 4 feet 6 inches to 5 feet, depending upon the size of the cows The former is the proper length for Jerseys, and the latter for cows of the size of Holsteins Some provision should be made to accommodate cows of different sizes, since they vary in any herd with age One plan often followed is to make the platform 4 inches longer at one end than at the other, with a gradual slant between The cows are then arranged according to size Another arrangement having much to recommend it is an adjustable stanchion so made that it may be set back 3 or 4 inches from the support, or set ahead the same distance for long cows

Ties and Stanchions There is a great variety of ties in use The most objectionable way to tie a cow is to fasten her to a manger where she must back up to lie down This is bound to result in filthy animals, since they are compelled to lie in their droppings The cow should be so fastened that she lies down exactly where she stands, or

a little forward if possible, and the platform should be the proper length so the manure drops in the gutter.

The most common ties in use are various forms of stanchions. There is no kind of tie that keeps the cows cleaner than the rigid stanchion, provided the platform and gutter are properly made. The rigid stanchion, however, is not well suited for a tie, as the cow has no freedom of movement and cannot lie in a natural position. Many

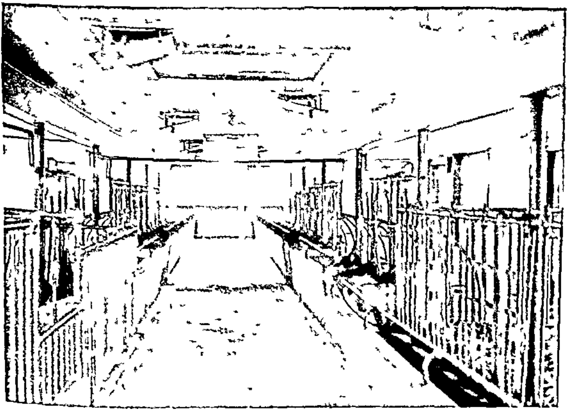


FIG. 96. Modern steel stanchions and box stalls of approved type. They are convenient, comfortable, and sanitary.

other forms of stanchions are in use that are reasonably satisfactory. One is hung on pegs at top and bottom, allowing a movement sideways. Another is hung on chains at top and bottom, which gives more freedom. For general use these improved forms of the stanchion find the most favor. Stanchions may be made of iron pipe or wood, but the former is the more sanitary and more durable, and equally comfortable for the animal.

The double-post slip chain tie is equally comfortable for the animal, but not so convenient to use.

Stanchion or chain ties may be attached to either iron or wooden framework as supports The iron is most sanitary, and has the additional advantage of being more sightly An iron pipe partition made of gas pipe, with the bottom set in the cement floor, is to be recommended

Box Stalls Box stalls to be used for maternity cases and for stabling sick animals should be provided, but these, along with pens

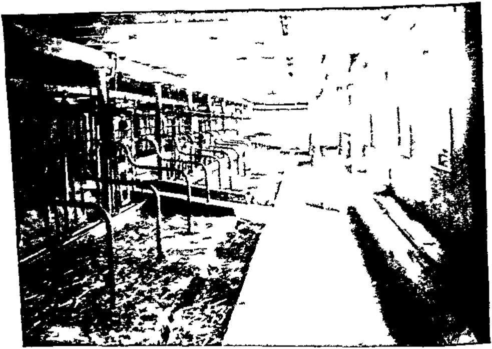


FIG. 97 Modern steel stalls with concrete mangers, platform, and alley

for calves should preferably be located in a part of the barn separate from the main herd The wing or section used for housing the milking herd should be used for that purpose alone, as this insures the least amount of noise and confusion High producing dairy cows can only do their best work in a peaceful environment

Water Supply and Drainage A modern cow barn should have a suitable drainage system so arranged that the liquid manure may be conducted to a manure cistern or else carried off to a natural drain some distance from the barn The gutters should have traps to

catch litter and prevent clogging up the drain tiles. Box stalls and calf pens require less bedding and are more sanitary if provided with floor drains.

Water under pressure is a necessity in the cow barn, both for watering the cows and for cleaning purposes. The individual drinking cup is now regarded as the most satisfactory method of keeping a continuous supply of water before the cows, and results in their

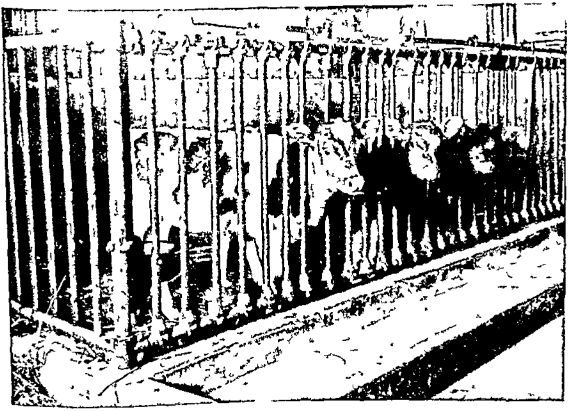


FIG 98 A modern calf pen of steel construction, and concrete feeding manger Steel construction of this type is also used for box stalls

drinking more water, especially in cold weather when the water in outdoor tanks approaches freezing temperature.

Ventilation. An abundance of pure air for animals of all kinds is scarcely less important than are proper methods of feeding. It is only within recent years that the full significance of an abundant supply of oxygen to animal life has been appreciated While there may be some excuse at times for insufficient or improper feeding of animals, there is none for failure to supply plenty of air.

Good ventilation for dairy barns is not only necessary from the standpoint of the health of the animals, but it is necessary for the most economical production of milk The air breathed by an animal is as indispensable as the hay and grain eaten, for neither assimilation of food nor generation of energy can take place without the consumption of a proportionate amount of pure air Dairymen are largely indebted to Professor King[1] for information on this subject, as well as for the practical system, known as the King system, of applying this knowledge

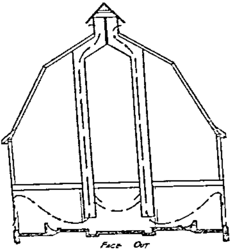


FIG 99 Ventilating flues according to the King system

The cow normally gives off oxygen, carbon dioxide, moisture, marsh gas (methane), and other volatile organic matter from the lungs and intestinal tract A cow weighing 1,000 pounds inhales 224 pounds of air in 24 hours, or about double the amount of weight of her food and drink This is at the rate of 3,542 cubic feet per hour To supply this amount of air for 20 cows will require a ventilating flue 2 by 2 feet, in which the air moves at a velocity of 295 feet per minute In providing pure air for stables, the cubic space per animal has little significance The important question is the movement and amount of fresh air provided

Forces producing ventilation There are three main forces that cause movement of air in a stable

1 The wind pressure against the side of the building which tends to force air into the building and out on the opposite side or upward through the ventilators
2. The wind in blowing across the top of a ventilating flue produces an outward suction
3 The difference in temperature between the air in the barn and that on the outside is due to the heat radiated by the animals and also the

[1] *Physics of Agriculture* p 350 (1901)

increased moisture content of the expired air. This causes an upward movement in a ventilating shaft by a force equal to the difference in weight of the air outside and within.

The King system. This is the system in general use in modern dairy barns. The main features consist of a large flue opening near the floor and extending above the roof of the stable for escape of the air and a series of smaller openings arranged on either side for the air to enter.

The object in taking the air from near the floor rather than at the ceiling is to remove the coldest air. The warmest air is found at the ceiling. The ventilating flue should be smooth inside, practically air-tight and, for good results, with no turns. The flue must have ample cross section. If too small, the friction is sufficient to prevent free movement of the air. In many cases, poor results in using this system are to be credited to a ventilating flue of too small size. None should be built less than 2 by 2 feet.

The ventilator flue should have an opening near the ceiling that may be opened when it is desired to increase the draft, and in warmer weather when there is no reason for conserving the heat of the stable. This opening should be regulated with a register.

Entrance for fresh air. Provision must be made for the entrance of outside air. This is taken in at the ceiling and mixes with the warm air. The intakes should extend downward in the wall, with the opening to the outside 3 feet or more lower than the opening in the barn. This is to prevent the warm air in the stable from flowing out. These intakes should be on all sides of the barn, to take advantage of all wind pressure. They should not be over 4 or 5 by 16 inches in size, and provided with registers to regulate the air passage.

The King system works only while the stable is closed. At such time as it is not desirable to close the barn, the air should be allowed to enter the ventilating flue through the opening near the ceiling. The King system cannot be expected to work in a barn which is not so tightly constructed that the air cannot find entrance or exit at other places. When properly installed, this system gives excellent results. A barn filled with animals will have no barn odor in the morning after being closed overnight where this system is used.

Fan or forced ventilation Recently the plan of using electrically driven fans for ventilating purposes has come into popular use This is made possible by the equipment of many farms with electrical power In using the fan system, elaborate ventilating flues are not necessary The fans are located near the ceiling of the barn The outlet is a flue extending directly through the wall of the barn to the outer air Inlets with damper control are generally provided The advantage of this system is that the installation is less expensive

The disadvantages are the expense for current to operate the motors and the vibrations of the motor and fan, which in time become rather disagreeable if not kept in good repair and adjustment

Window ventilation Some well-constructed barns depend upon hinged windows for ventilation These are usually hinged at the bottom, so that the top may be tilted inward to the desired extent Careful, constant attention to this plan may give fair results The movement of air in this case is dependent upon wind pressure and, furthermore, the warmest and not the coldest air is removed Windows are not a satisfactory means of ventilation in the winter season, as cross-drafts are developed between windows, and much warm air escapes

Planning to Save Labor In planning a modern barn, due consideration should be given to the installation of modern labor-saving devices Most reductions in the cost of milk production in the future will come from the reduction in the use and costs of labor Manure is now removed from the barn by mechanical manure carriers or in a litter carrier or truck, and the same system is employed in carrying feed from the feed room to the cow barn A carefully planned arrangement of feed rooms, silos, and milk house will result in more efficient handling of the barn work It must be remembered that the barn man will spend approximately two thousand hours per year in a barn housing the average herd of ten to fifteen cows Where present-day high wages for labor must be paid from milk income or earned from this product, great care must be given to keeping labor at a minimum These hours should be pleasant and enjoyable, or dairying becomes an unecessary drudgery

CHAPTER XXXIII

Handling Manure—Material for Bedding

Composition of Manure. In all countries where agriculture has been highly developed, the value of barnyard manure is fully appreciated. It is saved with great care, and applied to the soil under the best conditions possible. In many of the older dairy sections of Europe the size of the manure pile is a measure of success of the dairy farmer. In purchasing feeds, the probable fertilizing value is taken into account, as well as the feeding value.

Large quantities of succulent feeds increase the proportion of liquid manure, and nitrogenous diets produce a manure rich in nitrogen.

Table 66 shows approximately the quantities of urine and dung excreted by cows per thousand pounds of live weight; the distribution of the various fertilizer elements; and value of the manure based on 15 cents per pound for nitrogen, 4 cents per pound for phosphoric acid, 5 cents per pound for potash, and 20 cents per hundred pounds for organic matter.

It is a fact often lost sight of in practice that the urine of animals contains by far the most valuable fertilizing constituents of the excreta. That point is brought out by the figures given, where it is shown that 8,000 pounds of urine excreted contain practically the same amount of nitrogen as the 18,000 pounds of dung, and that of the total of 125 pounds of potash excreted, 80 pounds pass off in the urine. On the basis of the values quoted, the value of the plant nu-

trients contained in the urine is \$13 60 as compared with \$13 10 for the dung, and one ton of liquid cow manure has a total value of \$3 65, or \$1 40 more than a ton of cow dung These figures emphasize the necessity of preventing the loss of this valuable part of the excrement The saving of the liquid manure by the use of good bedding will more than offset the cost of the bedding This is seldom recognized by even the best farmers and dairymen

Table 66 Amount and Composition of Manure Excreted by a 1,000 Pound Dairy Cow

	URINE	DUNG	TOTAL
	Lbs	Lbs	Lbs
Pounds produced per year	8 000	18 000	26 000
Pounds dry matter contained	560	3 600	4 160
Pounds of nitrogen	64	63	127
Pounds phosphoric acid	trace	36	40
Pounds potash	80	45	125
Value plant nutrients	\$13 60	\$13 10	\$26 70
Value of organic matter	1 10	7 20	8 30
Total commercial value	14 70	20 30	35 00
Value one ton manure	3 65	2 25	5 90

Value of Manure as Measured by Crops It is recognized that the fairest valuation of barnyard manure is to measure the increase in crops resulting from its application An abundance of data are available on this subject Snyder[1] of the Minnesota Experiment Station secured a return of from \$2 to \$3 a ton when he applied manure to the soil, the larger figure being realized when the soil was one of low fertility This value represented the actual increase in crops produced in tests covering five years At this rate the manure from a dairy cow would be worth \$25 to \$30 a year

Wiancko[2] reports that "with present prices of crops, manure applied at a normal rate will produce crop increases worth from \$2 to over \$8 per ton of manure according to the fertility of the soil and

[1] Annual Report Minnesota State Dairyman s Assoc p 246 (1950)
[2] Purdue Agricultural Experiment Station Bulletin 222 (1918)

the crop grown. The average return in the seven fields reported has been $5 per ton of manure applied." Experiments by the Ohio Experiment Station covering fourteen years showed an average value of $3.31 to the ton of manure.

Amount of Fertility Returned by Manure. The proportion of the fertilizing constituents of the ration that is returned in the excrement depends upon the use to which the animal is putting the food. A fattening animal, or a dry cow, returns a high percentage, while the cow milking liberally uses a considerable proportion in the manufacture of the milk. Taking into account the young stock, the dry cows, and the cows in milk in proportions found on the farm, it is, according to Hart,[3] safe to assume that at least 80 per cent of the fertilizing constituents present in the feed used are voided in the liquid and solid excreta. The cow in milk, according to Warren,[4] voids approximately the following proportion of her food intake as excrement.

	PER CENT
Dry matter	45.5
Organic matter	43.3
Nitrogen	44.3
Mineral matter	63.6

If organic matter is needed in the soil, it may be fed dairy cows and there will still be nearly half for use in the fertilizer. The same is true for nitrogen, potash, and phosphorus.

Losses in Manure. Not all the manure produced by an animal reaches the field, and losses are due principally to leaching, fermentation, failure to save the liquid, and dropping outside the barn. Unless the manure is hauled immediately to the fields, there is bound to be some loss of fertilizer constituents, regardless of what method of storage is used; but every effort should be made to handle the manure in such a way as to reduce the losses to a minimum. The New Jersey Experiment Station[5] found that when solid cow manure was exposed to ordinary leaching for 109 days, it lost 37.6 per cent of its nitrogen, 51.9 per cent of its phosphoric acid, and 47.1 per cent of its potash.

[3] Wisconsin Experiment Station Bulletin 221 (1912).
[4] Eckles and Warren, *Dairy Farming*, p. 231. The Macmillan Co., New York (1916).
[5] Voorhees, Bulletin 150 (1901).

Mixed dung and urine lost in the same time 51 per cent of its nitrogen, 51 1 per cent of its phosphoric acid, and 61 per cent of its potash Over half of the total value was lost in less than four months' exposure to ordinary weather The loss in fertilizer by the leaching of one cow's manure would amount to $12 50 per year It would add 25 cents per 100 pounds to the cost of milk from cows producing 5,000 pounds per year These losses, especially of nitrogen, are partly accounted for by fermentations which set the ammonia free and make the other constituents more soluble That protection and care of manure pay well is demonstrated bv the results of an experiment at the Cornell Experiment Station[6] Five tons of cow manure were packed lightly in a box and exposed to the elements from April to October The losses during that period amounted to 49 per cent in total weight, 41 per cent of the nitrogen, 19 per cent of the phosphoric acid, and 8 per cent of the potash One of the greatest losses in fertilizing value results from the failure to save the liquid excrement of the animal To prevent this loss, the floor, including the gutter behind the animals, must be watertight Besides, enough litter must be used to absorb the urine so that none escapes when the manure is recovered from the barn, or else drains must be provided to conduct the liquids to a cistern

Preservation of Manure The fermentations in manure are checked by using plenty of litter to absorb the liquid manure A small amount of gypsum may be sprinkled on the moist manure as a means of helping to fix the ammonia The most important things to be done to preserve the manure are to use sufficient litter for absorbents and where it is necessary to store the manure some time before application to the soil, to keep it compact, moist, and protected from leaching In the eastern states it is common practice to use a manure cellar under the barn The manure is usually dropped through trap doors from above Large doors are arranged so that wagons can be backed or driven into the manure cellar for loading Land plaster is generally used to keep down the odors The manure is hauled out to the field in the spring or summer This method preserves the manure fairly well, especially when it is kept compact The disadvantage of such an

[6] Roberts and Wing, Bulletin 13 (1889)

arrangement is that it makes an admirable breeding place for flies and is also generally unsanitary.

Another provision made for protecting manure is an open shed. In some cases this is in the form of a lean-to along the side of the barn, and the manure is thrown out of the windows under this shed. A much better plan is to build a shed over a shallow pit some distance from the barn, and to haul the manure to it with a litter carrier. With this plan the urine is generally drained into the pit which contains the manure, a concrete bottom and sides preventing escape into the ground.

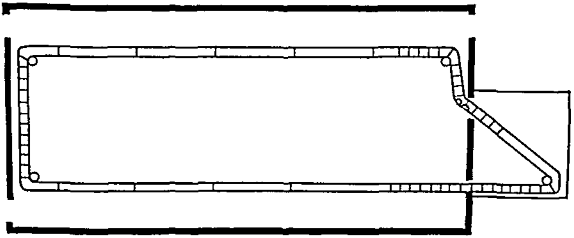


FIG. 100. Layout of endless-apron-type cleaner where land slopes away from end of the barn, permitting a manure spreader to drive under the extended gutter. This is all in one plane, and no elevator is needed

It is believed by some authorities that if an impervious floor is provided, sloping toward the center or built in the form of a pit with sides, a roof is not needed, and that the rain is beneficial rather than harmful, since leaching cannot occur and the necessary moisture to help prevent the escape of ammonia is provided. The throwing of manure out under the eaves of the barn results necessarily in the loss of much of its value by excessive leaching, and at the same time it is very objectionable in a sanitary way to have a large accumulation of manure through which cows must wade and in which flies will breed. A barnyard cannot be kept in good condition unless such accumulation of manure is avoided.

Handling Manure. One of the difficult problems in disposing of

manure is handling the urine. As already pointed out, it is the most valuable part of the manure, but is often allowed to go to waste. There are two systems in common use for handling urine. One is an underground cistern into which the urine goes through suitable drains from the gutters. This accumulated urine is at intervals pumped into a tank wagon and distributed over the fields from a sprinkler, or a portion is pumped over the solid manure on the spreader before it is taken to the field. If the liquid is allowed to remain in the cistern too long, large losses of nitrogen result from fermentation. The preservation of the liquid manure by means of a cistern and spreading it on the field involves some serious difficulties, and is not to be recommended if it is practicable to supply sufficient amount of bedding to absorb the liquid, or to run the liquid manure through a drain into a manure pit.

FIG. 101. Mechanical barn cleaners reduce heavy dirty labor in handling manure

The method of handling manure which has met with the greatest favor among dairymen in recent years is loading it directly from the barn into a manure spreader. The barn is so arranged that the spreader may be driven through the barn and loaded from the gutters, or an overhead carrier is used, with the track extending into the yard, so arranged that the load may be dumped into the spreader.

When a load has accumulated, it is hauled to the field and scattered. One objection of this plan is that in freezing weather the manure must be unloaded daily to prevent freezing. At times the

ground is soft, so it is not desirable to drive over it with a load. It often happens that the ground where it is intended to apply the manure is not ready for the application. There is also some difference of opinion regarding the extent to which losses occur from the washing of recently spread manure when snow melts or rain falls on frozen ground. Analyses made by the Ohio Experiment Station[7] show that manure handled in the usual manner by piling in the barnyard lost over one third of its value by exposure to three months of winter and spring weather. Manure applied directly to a field from the stall showed a value of $2.96 a ton measured by increase in crops grown, while manure taken from the yard after three months' exposure showed a value of $2.15, a loss in value of 27 per cent.

Taking everything into account, the plan of spreading the manure directly from the stable is to be recommended, but it may be impossible or impracticable to do this at all times. Certainly the daily removal of manure either directly to the field or to pits a suitable distance from the barn is one of the most effective means of fly control.

The litter carrier. Perhaps the most valuable part of modern barn equipment is the litter carrier. It makes possible a decided saving in the time required to care for a herd of cattle and lessens the disagreeable features connected with the handling of the manure. The advantages are that the carrier is easily loaded and moved, and that it is possible to haul the manure as far from the barn as desired or to place the spreader on a lower level and dump into it directly.

Mechanical manure carriers. Recently mechanical manure-removing equipment has been placed on the market by a number of manufacturers. These systems generally consist of an endless chain with lugs which work in the gutters and remove all litter in a few minutes. They are best installed in new barns designed for their use. They are great labor savers and are becoming very popular wherever used.

Bedding. No satisfactory plan has been devised to do away with the necessity of providing bedding of some kind. Bedding is used primarily to keep animals warm and clean, and the material that

[7] Ames and Gaither, Bulletin 246, p. 725 (1912).

will do this most satisfactorily and at the same time contribute to the comfort of the animals must be considered the best

Another purpose, and almost as important as the one of keeping the animals clean, is as an absorbent for urine beyond that absorbed by the dung Table 67 gives data regarding the absorptive powers of common bedding material as found by trial by Doane[8] at the Maryland Experiment Station

Table 67 *Absorptive Power of Bedding Materials*

MATERIAL	LBS OF WATER ABSORBED PER LB OF BEDDING	LBS OF BEDDING REQUIRED TO ABSORB LIQUID MANURE FROM 1 COW 16 HOURS	LBS OF BEDDING REQUIRED TO ABSORB FOR 24 HOURS
Cut stover	2 5	2 8	4 0
Cut wheat straw	2 0	3 3	5 0
Uncut wheat straw	2 0	3 3	5 0
Sawdust	0 8	8 3	12 5
Shavings	2 2	3 0	4 4

Water retained by 100 pounds of bedding material after 24 hours was found by Whisenand[9] to be as follows

	LBS
Oat straw (whole)	250
Cut oat straw (about ½ inch lengths)	244
Wheat straw	210
Mixed shavings	119 to 130
Fine dry white-pine shavings	185
Mixed sawdust	160

In a practical comparative test of oat straw and shavings for bedding dairy cows, he also found that 7 24 pounds of uncut oat straw and 10 15 pounds of shavings were used per day for each animal His conclusions were that oat straw retained approximately twice as much water as shavings and from 15 to 20 per cent more than wheat straw, and that to keep animals bedded from 40 to 82 per cent more shavings than oat straw and 9 to 18 per cent more wheat straw than oat straw were required

[8] Bulletin 104 (1905)

[9] *Journal Agricultural Research* 14 187 190 (1918)

Materials for Bedding. Good material for bedding should be itself clean—which means, primarily, free from dust. The material to be used on a certain farm will depend upon what is available, and, when it is purchased, upon the comparative cost. The problem of a suitable supply of bedding at a reasonable cost is a serious one in regions such as the eastern states where the growing of cereals is limited and as a result little home-grown straw is available. Wheat straw ranks first as a bedding material. It is clean and has fair absorptive powers. Oat straw usually contains some dust but otherwise has about the same value. Sometimes corn fodder is either shredded or run through a cutting machine and fed in the barn, the refuse making satisfactory bedding.

In localities where peat is common, it is sometimes dug in the summer, allowed to dry in the field, and stored under cover when dry. It is found to make good bedding, having especially good absorptive powers. In the eastern states, shavings, sawdust, and wood chips are largely used. From a sanitary standpoint sawdust stands first as bedding material, followed by shavings. These materials are free from the large number of bacteria and molds which often accompany straw. However, bedding of this class does not add as much fertility to the soil, as is the case when wheat or oat straw is used. Wood chips are a recent development of special mechanical wood chippers which will chip farm wood lot poles up to 6 inches into cheap bedding. Some objections have been raised to the use of sawdust and shavings as bedding material. Sawdust makes manure so light that loss of ammonia and sometimes loss from firefanging occurs. Applied in large quantities to the soil it may be injurious from the effect of the acids set free, particularly tannic acid in the case of oak sawdust. The reasonable use of sawdust or wood chips on most soils, however, is not injurious, and may even be beneficial. Some of our best soils are the results of countless ages of tree growth and decomposition, so that there is little validity to this objection to the use of shavings, sawdust, or wood chips for bedding in the dairy barn.

APPENDIX

Table 68 Digestible Nutrients in Feeds*

	TOTAL DRY MATTER	DIGESTIBLE NUTRIENTS		MINERALS	
		Protein	Total	Calcium	Phosphorus
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
CONCENTRATES					
Corn, dent No 2	85 0	6 6	80 1	0 02	0 27
Corn and cob meal	86 1	5 3	73 2	—	0 22
Hominy feed 5% fat	90 4	8 0	84 5	0 22	0 71
Corn gluten meal	91 4	36 6	80 2	0 13	0 38
Corn gluten feed	90 9	21 9	76 0	0 48	0 82
Corn bran	90 6	5 5	69 4	0 03	0 27
Wheat, average all types	89 5	11 1	80 0	0 04	0 39
Wheat bran, all analyses	90 1	13 7	70 2	0 14	1 29
Wheat flour middlings	89 2	16 1	78 9	0 09	0 71
Wheat flour middlings and screenings	89 6	16 0	78 4	0 14	0 68
Wheat screenings, good grade	90 4	10 0	68 7	0 44	0 39
Red dog flour	89 0	16 0	85 6	0 07	0 51
Oats (except Pacific Coast)	90 2	9 4	70 1	0 09	0 34
Barley (common, except Pacific Coast)	89 4	10 0	77 7	0 06	0 37
Malt sprouts	92 6	20 6	70 9	—	—
Brewers' grains, dried 25% protein or over	92 9	22 1	67 1	0 29	0 48
Rye	89 5	10 0	76 1	0 10	0 33
Rice grain (rough rice)	88 8	6 0	70 2	0 08	0 32
Kafir grain	89 8	8 8	81 6	0 02	0 31
Milo grain	89 4	8 8	80 1	0 03	0 30
Pea seed field	90 7	20 1	77 9	0 17	0 51
Sorghum seed sweet	89 2	5 8	77 5	0 02	0 28
Soybean seed	90 0	33 7	87 6	0 25	0 59
Soybean oil meal, 41% protein	90 9	37 1	78 5	0 26	0 59

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Table 68 (*Continued*)

	DRY MATTER TOTAL	DIGESTIBLE NUTRIENTS		MINERALS	
		Protein	Total	Calcium	Phosphorus
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Soybean oil meal, 44–45% protein	91 3	38 1	78 9	0 31	0 68
Peanut oil meal, all analyses	93 0	39 6	82 4	0 16	0 54
Cottonseed meal, 45% protein and over	93 5	37 9	78 4	0 22	1 13
Cottonseed whole pressed, 28% protein	93 5	20 3	59 8	—	—
Flaxseed	93 8	21 8	108 6	0 26	0 55
Linseed meal, old process	91 0	30 8	77 2	0 39	0 87
Linseed meal, solvent process	90 4	31 0	72 3	—	—
Coconut oil meal (high in fat)	93 7	17 8	83 3	—	—
Beet pulp, dried	90 1	4 3	67 8	0 67	0 08
MILK AND ITS PRODUCTS					
Whole milk (cows—liquid)	12 8	3 3	16 3	0 12	0 09
Whole milk dried	96 8	22 3	118 7	—	—
Skim milk separator	9 5	3 4	8 7	0 13	0 10
Skim milk, dried	94 2	31 2	80 7	1 30	1 03
Buttermilk	9 4	3 3	9 1	0 14	0 08
DRIED ROUGHAGE					
Alfalfa hay, all analyses	90 5	10 5	50 3	1 47	0 24
Clover hay, red, all anal	88 1	7 1	52 2	1 35	0 19
Clover hay, alsike	88 9	8 1	53 2	1 15	0 23
Clover hay, sweet, first yr	91 8	11 9	50 3	1 37	0 26
Field peas hay	89 3	10 6	55 1	1 22	0 25
Cowpea hay	90 4	12 3	51 4	1 37	0 29
Soybean hay, all analyses	88 0	9 6	49 0	0 94	0 24
Oat-and pea hay	89 1	8 6	52 9	0 72	0 22
Timothy hay, all analyses	89 0	2 9	48 9	0 23	0 22
Red top hay	91 0	3 2	48 7	0 38	0 23
Prairie hay, western good	90 7	2 1	49 6	0 36	0 18
Millet hay, foxtail varieties	87 6	4 9	50 0	0 29	0 16
Sudan grass hay	89 3	4 3	48 5	0 36	0 26
Corn fodder well-eared, dry	91 1	3 8	58 8	0 24	0 16
Corn stover, dry	90 6	2 1	51 9	0 29	0 05
Kafir fodder, dry	90 0	4 5	53 6	0 35	0 18

Table 68 (*Continued*)

	TOTAL DRY MATTER	DIGESTIBLE NUTRIENTS		MINERALS	
		Protein	Total	Calcium	Phosphorus
Sorghum fodder, dry	88.8	3.3	52.4	0.34	0.12
Lespedeza hay, all anal.	89.2	6.4	47.5	0.98	0.18
Kudzu hay	89.0	10.7	49.2	2.78	0.21
SUCCULENT ROUGHAGE—SILAGE					
Corn, dent, mature, all anal.	27.4	1.2	18.1	0.10	0.06
Corn, dent, immature	20.4	0.9	13.0	—	—
Corn stover silage	23.0	0.6	13.0	0.08	0.01
Sorghum, sweet	25.3	0.8	15.2	0.08	0.04
Alfalfa, wilted	36.0	4.1	21.2	0.51	0.12
Clover, sweet, wilted	40.0	6.2	22.5	—	—
Soybean, wilted	33.2	3.9	19.1	0.45	0.12
Sunflower	22.6	1.0	12.2	0.39	0.04
Beet top silage, sugar	31.6	2.6	14.9	0.31	0.07
Grass silage, some legumes, wilted, molasses added	35.0	2.7	19.8	0.32	0.12
GREEN FORAGE					
Alfalfa, green, all anal.	25.3	3.4	14.7	0.35	0.07
Clover, red	25.0	2.8	16.6	0.38	0.06
Clover, alsike	22.2	2.7	14.5	0.29	0.06
Clover, Ladino, pasture	16.3	3.7	11.4	0.20	0.07
Peas, field	17.3	2.9	12.2	0.24	0.05
Cowpeas	16.3	2.2	10.8	0.25	0.05
Soybeans, forage	24.0	3.2	15.2	0.20	0.07
Oats and peas	22.5	2.4	14.2	0.17	0.07
Corn fodder, dent	24.0	1.2	16.3	0.06	0.05
Kafir fodder	23.6	1.2	14.4	0.09	0.05
Oat pasture	14.0	2.4	9.1	0.06	0.09
Rye pasture	19.7	4.0	13.2	0.13	0.10
Bluegrass pasture, Kentucky	30.2	3.9	19.2	0.16	0.13
Alfalfa and brome grass, one-half alfalfa	22.4	3.6	14.6	0.30	0.07
ROOTS					
Sugar beets	16.4	1.2	13.7	0.04	0.04
Mangels	9.2	0.9	7.0	0.01	0.03
Turnips	9.3	0.9	7.8	0.06	0.02
Rutabagas	11.1	1.0	9.5	0.05	0.03
Potatoes	21.2	1.1	17.9	0.01	0.05
Pumpkins, field, entire	10.4	1.1	9.0	—	0.04

Table 69 Mineral Elements of Selected List of Common Feeds, Parts per 100*

FEED	CALCIUM	PHOSPHORUS	POTASSIUM	SODIUM	MAGNESIUM	SULPHUR	CHLORINE
Corn dent No 2	0 02	0 27	0 27	0 01	0 10	0 12	0 06
Corn gluten feed	0 48	0 82	0 54	0 70	0 57	0 09	0 33
Oats	0 09	0 34	0 43	0 09	0 14	0 21	0 12
Wheat	0 04	0 39	0 42	0 06	0 14	0 20	0 08
Wheat *bran*	0 14	1 29	1 23	0 06	0 59	0 21	0 04
Wheat middlings	0 09	0 71	0 89	0 07	0 32	0 20	0 04
Cottonseed meal, 45%	0 22	1 13	—	—	0 55	—	—
Linseed meal *o p*	0 39	0 87	1 24	0 11	0 55	0 38	0 04
Soybean meal	0 29	0 66	1 77	0 42	0 26	0 33	0 04
Milk liquid	0 12	0 09	0 14	0 05	—	—	0 20
Bone meal raw	23 05	10.22	0 23	0 74	0 24	0 17	0 09
Alfalfa hay	1 47	0 24	2 05	0 13	0 29	0 32	0 37
Clover hay	1 35	0 19	1 43	0 18	0 33	0 14	0 70
Timothy hay	0 23	0 20	1 50	0 16	0 12	0 12	0 55
Corn silage	0 10	0 06	0 30	0 01	0 05	0 04	0 05
Corn stover	0 29	0 05	0 67	0 06	0 22	0 15	0 28
Beet pulp, dried	0 62	0 09	1 63	—	0 17	0 39	—
Potatoes	0 01	0 05	0 48	0 02	0 03	0 02	0 06

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Table 70 Number of Dairy Cattle Registered in Selected Years, by Breeds, in the United States*

YEAR	AYRSHIRE	BROWN SWISS	GUERNSEY	HOLSTEIN FRIESIAN	JERSEY	TOTAL
1935	13,854	6,420	45,037	76 885	48,222	190,418
1940	16,237	10 473	56 860	145,423	48,527	277,520
1945	21,517	18,804	76 897	113,446	51,150	281,814
1950	24,236	22,721	94 901	184,246	68 979	395,083
1951	25 463	25,763	93,629	191 638	68 651	405,144
1952	23,208	23 099	113,909	189,690	71,513	421,419
1954	22 993	22 854	81 545	195 963	64 072	387,427

* *Agricultural Statistics* U S D.A. (1953) and data from Breed Associations.

Table 71. Gestation Table. The Average Period of Gestation with Cattle is 282 Days

Date of		Date of		Date of	
Service	Birth	Service	Birth	Service	Birth
Jan. 1	Oct. 8	May 6	Feb. 11	Sept. 8	June 16
6	13	11	16	13	21
11	18	16	21	18	26
16	23	21	26	23	July 1
21	28	26	Mar. 3	28	6
26	Nov. 2	31	8	Oct. 3	11
31	7	June 5	13	8	16
Feb 5	12	10	18	13	21
10	17	15	23	18	26
15	22	20	28	23	31
20	27	25	April 2	28	Aug. 5
25	Dec. 2	30	7	Nov. 2	10
Mar. 2	7	July 5	12	7	15
7	13	10	17	12	20
12	18	15	22	17	25
17	23	20	27	22	30
22	28	25	May 2	27	Sept. 4
27	Jan. 2	30	7	Dec. 2	9
April 1	7	Aug. 4	13	7	14
6	12	9	17	12	19
11	17	14	22	17	24
16	22	19	27	22	29
21	27	24	June 1	27	Oct 4
26	Feb. 1	29	6		
May 1	6	Sept 3	11		

Table 71a. Gestation Variation between Dairy Breeds*

Breed	Average gestation length
Ayrshire	278 7 days
Brown Swiss	290 8 days
Guernsey	284 0 days
Holstein	278 9 days
Jersey	279 3 days

* Breeding Committee, American Dairy Science Association

Table 72. National Research Council* Recommended Daily Nutrient Allowances for Dairy Cattle
(Based on Air-Dry Feed Containing 90 Per Cent Dry Matter)

Body Weight Pounds	Expected Gain		Daily Allowances per Animal[1]						
	Small Breeds pounds	Large Breeds pounds	Total Feed pounds	Digestible Protein pounds	T D N pounds	Calcium grams	Phosphorus, grams	Carotene, milligrams	Vitamin D I U
Normal Growth of Dairy Heifers									
50	0.5	—	0.9	0.20	1.0	4	3	6[2]	200
100	1.0	0.8	2.0	0.40	2.0	8	6	6	400
150	1.3	1.4	4.0	0.50	3.0	12	8	9	600
200	1.4	1.6	6.0	0.60	4.0	16	11	12	800
400	1.2	1.8	11	0.80	6.5	20	15	24	[3]
600	0.8	1.4	15	0.85	8.5	18	15	36	
800	1.1	1.2	19	0.90	10.0	16	15	48	
1000	—	1.3	22	0.95	11.0	15	15	60	
1200	—	1.2	24	1.00	12.0	15	15	72	
Maintenance of Mature Cows[4]									
800	—	—	14	0.50	6.8	8	8	48	[3]
1000	—	—	16	0.60	8.0	10	10	60	
1200	—	—	18	0.70	9.2	12	12	72	
1400	—	—	21	0.80	10.5	14	14	84	
1600	—	—	23	0.87	11.4	16	16	96	
Reproduction (Add to Maintenance during Last 2 to 3 Months[5])									
	2.0	2.0	8.0	0.60	6.0	12	7	30	[3]
Lactation (Add to Maintenance for Each Pound of Milk)									
	3.0% fat		—	0.040	0.28	1	0.7	[5]	[5]
	4.0% fat		—	0.045	0.32	1	0.7		
	5.0% fat		—	0.050	0.37	1	0.7		
	6.0% fat		—	0.055	0.42	1	0.7		
Maintenance of Breeding Bulls									
1200	—	—	18	1.00	10.3	12	12	72	[3]
1600	—	—	22	1.20	12.9	16	16	96	
2000	—	—	27	1.45	15.6	20	20	120	
2400	—	—	31	1.60	18.2	24	24	144	

* Taken by permission from 1950 Report, National Research Council.

[1] Thiamine riboflavin niacin, pyridoxine pantothenic acid, and vitamin K are synthesized by bacteria in the rumen and it appears that adequate amounts of these vitamins are furnished by a combination of rumen synthesis and natural feedstuffs. Manganese iron copper and cobalt are clearly essential but the amounts needed are not known. For growth, 0.6 gm magnesium is needed per 100 pounds of body weight.

[2] Calves should receive colostrum the first few days after birth, as a source of vitamin A and other essential factors.

[3] While vitamin D is known to be required the data are inadequate to warrant specific figures for older growing animals and for maintenance reproduction and lactation. The vitamin D allowance has been increased from 200 to the present 400 I.U. per 100 pounds body weight to provide a safety margin comparable to that of other nutrients.

[4] When calculating the allowances for lactating heifers that are still growing, it is recommended that the figure for growth rather than maintenance be used.

[5] When adequate amounts of vitamins A and D are fed for normal reproduction, extra amounts will probably not stimulate milk production but will increase the vitamin content of the milk.

Table 73. Estimated Carotene Content of Feeds in Relation to Appearance and Methods of Conservation*

FEEDSTUFF	CAROTENE
Fresh green legumes and grasses, immature	15 to 40
Dehydrated alfalfa meal, fresh, dehydrated without field curing, very bright green color	110 to 135
Dehydrated alfalfa meal after considerable time in storage, bright green color	50 to 70
Alfalfa leaf meal, bright green color	60 to 80
Legume hays, including alfalfa, very quickly cured with minimum sun exposure, bright green color, leafy	35 to 40
Legume hays, including alfalfa good green color, leafy	18 to 27
Legume hays, including alfalfa, partly bleached, moderate amount of green color	9 to 14
Legume hays including alfalfa, badly bleached or discolored, traces of green color	4 to 8
Nonlegume hays, including timothy, cereal, and prairie hays, well cured, good green color	9 to 14
Nonlegume hays, average quality, bleached some green color	4 to 8
Legume silage	5 to 20
Corn and sorghum silages, medium to good green color	2 to 10
Grains, mill feeds, protein concentrates, and by-product concentrates, except yellow corn and its by products	01 to 0 2

* This table was prepared by H R Builbert, Davis California Taken from the 1950 Report of the Committee on Animal Nutrition of the National Research Council

Table 74 Estimated Weight of Settled Corn Silage*

DEPTH OF SILAGE	ESTIMATED WEIGHT OF SILAGE TO THE CUBIC FOOT AT THIS DEPTH	AVERAGE WEIGHT OF SILAGE TO THE CUBIC FOOT TO THIS DEPTH	DIAMETER OF SILO					
			10 ft	12 ft	14 ft	16 ft	18 ft	20 ft
Feet	Lbs	Lbs	Tons	Tons	Tons	Tons	Tons	Tons
1	32 0	32 0	1 2	1 8	2 4	3 2	4 0	5 0
2	32 7	32 4	2 5	3 6	4 9	6 5	8 2	10 1
3	33 4	32 7	3 8	5 5	7 5	9 8	12 4	15 4
4	34 1	33 1	5 1	7 4	10 1	13 3	16 8	20 7
5	34 8	33 4	6 5	9 4	12 8	16 7	21 2	26 2
6	35 4	33 7	7 9	11 4	15 5	20 3	25 6	31 7
7	36 0	34 1	9 3	13 5	18 3	23 9	30 3	37 4
8	36 6	34 4	10 8	15 5	21 1	27 6	34 9	43 2
9	37 4	34 7	12 2	17 6	24 0	31 3	39 6	49 0
10	38 0	35 0	13 7	19 7	26 9	35 1	44 4	54 9
11	38 4	35 3	15 2	21 9	29 8	39 0	49 3	60 9
12	38 8	35 6	16 7	24 1	32 8	42 9	54 2	67 0
13	39 2	35 9	18 3	26 3	35 9	46 9	59 2	73 2
14	39 6	36 2	19 9	28 6	39 0	50 9	64 3	79 5
15	40 0	36 4	21 4	30 8	42 0	54 8	69 3	85 7
16	40 2	36 7	23 0	33 2	45 2	59 0	74 5	92 1
17	40 4	36 9	24 6	35 4	48 3	63 0	79 6	98 4
18	40 6	37 1	26 2	37 7	51 4	67 1	84 8	104 8
19	40 8	37 3	27 8	40 0	54 5	71 2	90 0	111 2
20	41 0	37 5	29 4	42 4	57 7	75 3	95 2	117 7
21	41 2	37 6	31 0	44 6	60 7	79 3	100 2	123 9
22	41 4	37 8	32 6	47 0	64 0	83 5	105 6	130 5
23	41 6	38 0	34 3	49 4	67 2	87 8	110 5	137 2
24	41 8	38 1	35 9	51 7	70 4	91 9	116 1	143 5
25	42 0	38 3	37 6	54 1	73 7	96 2	121 6	150 3
26	42 2	38 4	39 2	56 4	76 8	100 3	126 8	156 7
27	42 4	38 6	40 9	58 9	80 2	104 7	132 3	163 6
28	42 6	38 7	42 5	61 2	83 4	108 9	137 6	170 1
29	42 8	38 9	44 3	63 7	86 8	113 3	143 2	177 1
30	43 0	39 0	45 9	66 0	90 0	117 5	148 5	183 6

* Eckles Reed and Fitch, Missouri Agricultural Experiment Station Bulletin 164 (1919)

When conditions of moisture and amount of grain are judged to be average, Table 74 is to be used as given. When conditions are extreme, the following modifications are suggested:

1. When the corn is put into the silo in a less mature condition than usual, for example, in the milk stage, or the beginning of the dough stage, add 10 to 15 per cent to the weights given in the table.
2. If the grain is unusually heavy in proportion to the stalk, add 5 to 10 per cent to the figures found in the table.
3. If the corn is considerably past the usual stage of maturity and clearly contains less water than usual, deduct 10 to 15 per cent.
4. If very little or no grain is present, deduct 10 per cent.

It is recommended that the same table be used for estimating the weight of sweet sorghum and Kafir silage.

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